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OPERATIONAL LANCHESTER-TYPE MODEL OF SMALL UNIT LAND COMBAT

Josef Smoler

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THESIS

OPERATIONAL LANCHESTER-TYPE MODEL
OF SMALL UNIT LAND COMBAT

by

Josef Smoler

September 1979

Thesis Advisor: J.G. Taylor

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Operational Lanchester-Type Model of Small Unit Land Combat		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; September 1979
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Josef Smoler		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		12. REPORT DATE September 1979
		13. NUMBER OF PAGES 114
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Lanchester-type Model

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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#20 - ABSTRACT - CONTINUED

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Operational Lanchester-Type Model of Small Unit Land Combat

by

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Major, Israel Army
B.S., Technion-Israel Institute of Technology, 1973

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
September 1979

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ABSTRACT

This thesis describes an operational Lanchester-type model of small-unit land combat. It is a time sequenced, deterministic, battalion-level, force-on-force model implemented on a digital computer. In comparison with other existing battalion level analytic models, this model contains some new modelling ideas about detection and fire allocation policies.

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I. INTRODUCTION

Although detailed combat models (such as high-resolution Monte Carlo simulations) are heavily used at the tactical level, some analysts and users still have doubts about the use of this kind of model. Detailed combat models (especially high-resolution Monte Carlo simulations) are costly to build, costly to run, require a staff of highly trained personnel to maintain, exercise and modify, are quite demanding in data-base requirements, not easily modified, essentially impossible to use to perform sensitivity and other parametric studies, and are not easily communicated to decision makers.

Though a detailed model is considered by many to be more realistic than an analytic model and to supply more information as output, one can definitely see that there is a price to pay for such detail. This is especially true if one considers some meaningful advantages of analytic models.

Analytic models in contrast are usually much simpler to use and both time and financial resources for their utilization are usually markedly reduced. They are very efficient for conducting sensitivity analysis and their results are readily interpretable, since the dynamics of the combat process are clearly and succinctly described by equations (i.e., they are an efficient tool for communication with decision makers). Analytic models are an

efficient tool for the user too, since they are usually more general thus facilitating their use under more diverse circumstances. Now that we have discussed the pros and cons of the two principal types of small-unit combat models, it remains for us to consider how to decide which one to develop and use under specific circumstances. What should one do to decide which type of model to use? Definitely there is no unique answer to this question. Furthermore, such an answer depends on considerations such as availability of time and money, level of accuracy desired, problem scenario, purposes of model use, etc. Since an analytic model is more abstract than a Monte Carlo simulation, one might ask himself: Do the two types of models describe the same combat process for the same given scenario?

Reference 5 describes a study that was conducted to compare the combat predictions generated by an analytical combat model to those predicted by a more detailed Monte Carlo simulation model. The analytical model was developed against an existing simulation model to determine whether both could generate comparable results. The analytic model was applied to replicate the processes as they were described in the simulation model and not as they might possibly occur in the real world. The conclusions of this study indicate good agreement and suggest that both models essentially describe the same process. In reference 4 it is suggested that the complex model should be used to educate

the analyst while a simple model should be used to communicate with the decision maker. In other words, complex models should be used as research tools to determine basic relations that can be presented to decision makers with simple easily-understood models. In this context the detailed model serves as the "back-up" for the simple model.

II. MOTIVATION

The BONDER/IUA and its derivatives BLDM and AMSWAG are analytical battalion-level combat models that have been and are currently widely used in the United States for defense planning purposes. After studying documentation for these models, the author decided to build his own small-scale version with certain important changes. For example, the detection and fire-allocation submodels in these models (at least to the extent that they are described in available documentary) have several features that appear to be at variance with both military experience and judgement. Reference 3 describes a sensitivity analysis of BLDM acquisition and firepower allocation models and shows that BLDM is relatively insensitive to changes in non-firing acquisition rates. The analysis explains that this insensitivity is a result of the firepower allocation logic and the fact that firing-cued probabilities in the model have been set to 0.99.

The study in reference 3 recommends that fire-cued acquisition probabilities considerably less than 0.99 should be used in the model and sections of search should be assigned weapon groups. It is also recommended that detection rates for targets lying within a group's primary search sector should be different from those for targets lying outside the sector. The author of this paper also could not strongly

agree with some of the basic assumptions of AMSWAG's detection and fire allocation models. AMSWAG conducts the battle in uniform time steps of 10 seconds each. AMSWAG's detection model keeps track of the comulative acquisition probability that each firer has against each target at any time t and combines this with the new probability of acquisition during the interval $(t,t+\Delta t)$. This process is continued as long as line-of-sight is not interrupted. When line-of-sight is interrupted, however, the cumulative probability of acquisition is set to zero and the process will start again if intervisibility again exists at a later point in the battle. According to the author's experience, the cumulative acquisition probability should not be set to zero immediately since the observer still has some idea where to expect the target to appear. The computation of detection probability for each observer against every target must consequently depend on both the observer status (i.e., whether or not the observer fires during the current time interval) and the target status (i.e., whether or not the target fires during the current time interval), whether the target is inside or outside the observer search sector or the observer field of view). This is not done by AMSWAG's detection model.

The author of this paper also did not find the AMSWAG's fire allocation model to be a realistic representation of military reality, and consequently has developed a new one based on his previous military experience.

As a result of the discussion above, an analytic battalion level combat model was developed. Although the model was programmed for a specific scenario, it can still be applied to other battalion-level scenarios with relatively few modifications because of its generality.

III. THE MODEL

A. GENERAL DESCRIPTION

The model developed in this thesis is a time sequenced, deterministic, battalion-level, force-on-force computer model. The scenario portrays a blue TOW company (3 platoons with 3 TOWS in each) deployed in 3 fixed platoon-sized defensive positions (see B1, B2 and B3 in figure 1). The opponent, a red tank company (3 platoons with 3 tanks in each) conducts an attack along 3 predetermined routes of advance toward the defensive positions. Each route nominally contains a platoon-sized force (see R1, R2 and R3 in figure 1). The model conducts the battle in uniform time steps of 10 seconds each. Figure 2 provides the general scheme for the sequence and flow of events in the model. Basically the sequence of events for each time interval (i.e., 10 seconds) contains five main phases: movement, detection, fire-allocation, attrition and battle-termination (see figure 3). The movement phase is applied to the Red units only. Generally, every Red unit is advanced to the next interval along the associated route unless this unit is destroyed alreay or is in firing status. (In this case the unit will be advanced only every certain number of time intervals.) The detection phase is basically an accumulation process. Detection probabilities during $(t,t+\Delta t)$ between any two opponent units are computed and combined

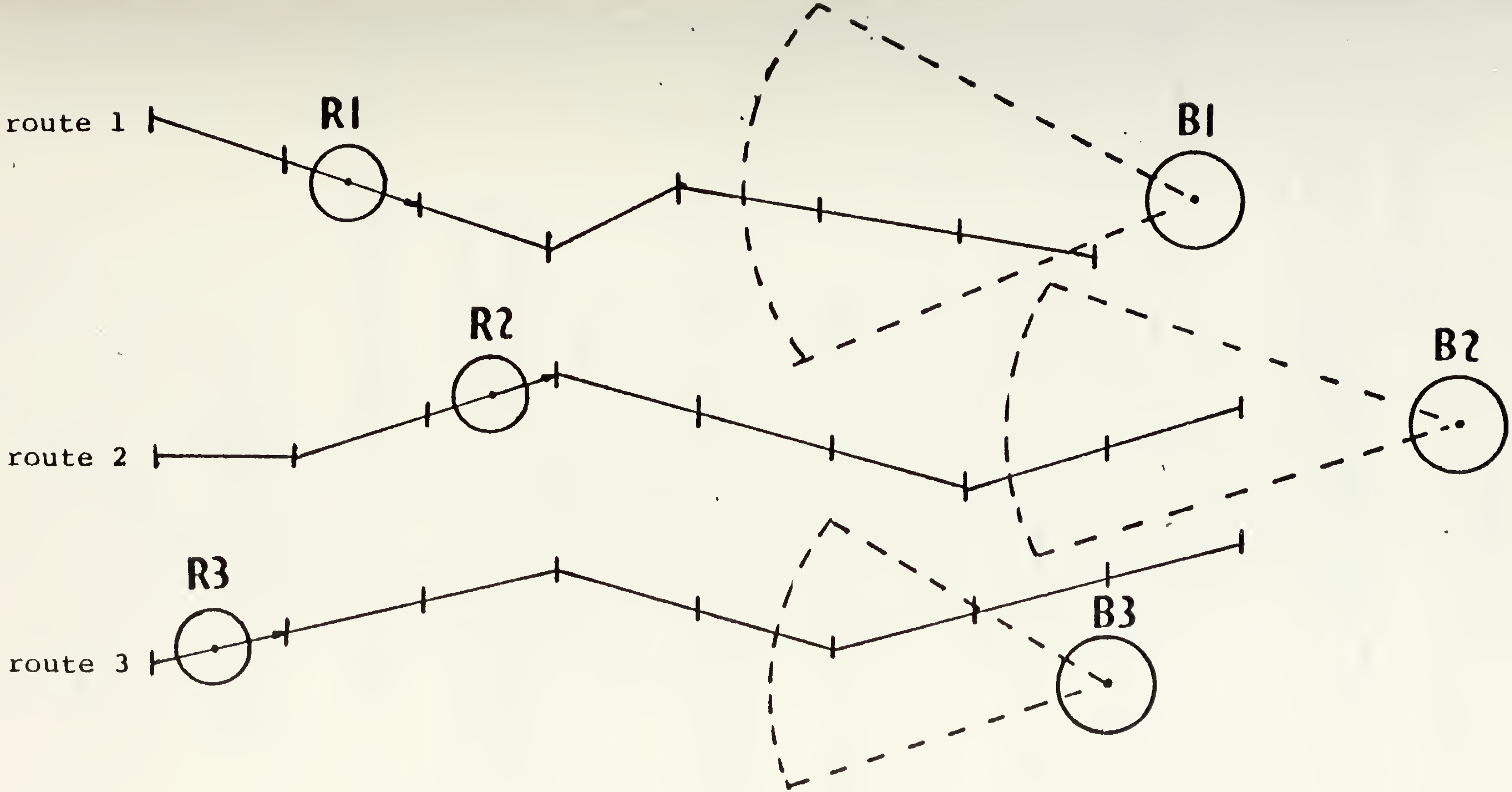

FIGURE 1. SCENARIO SCHEME

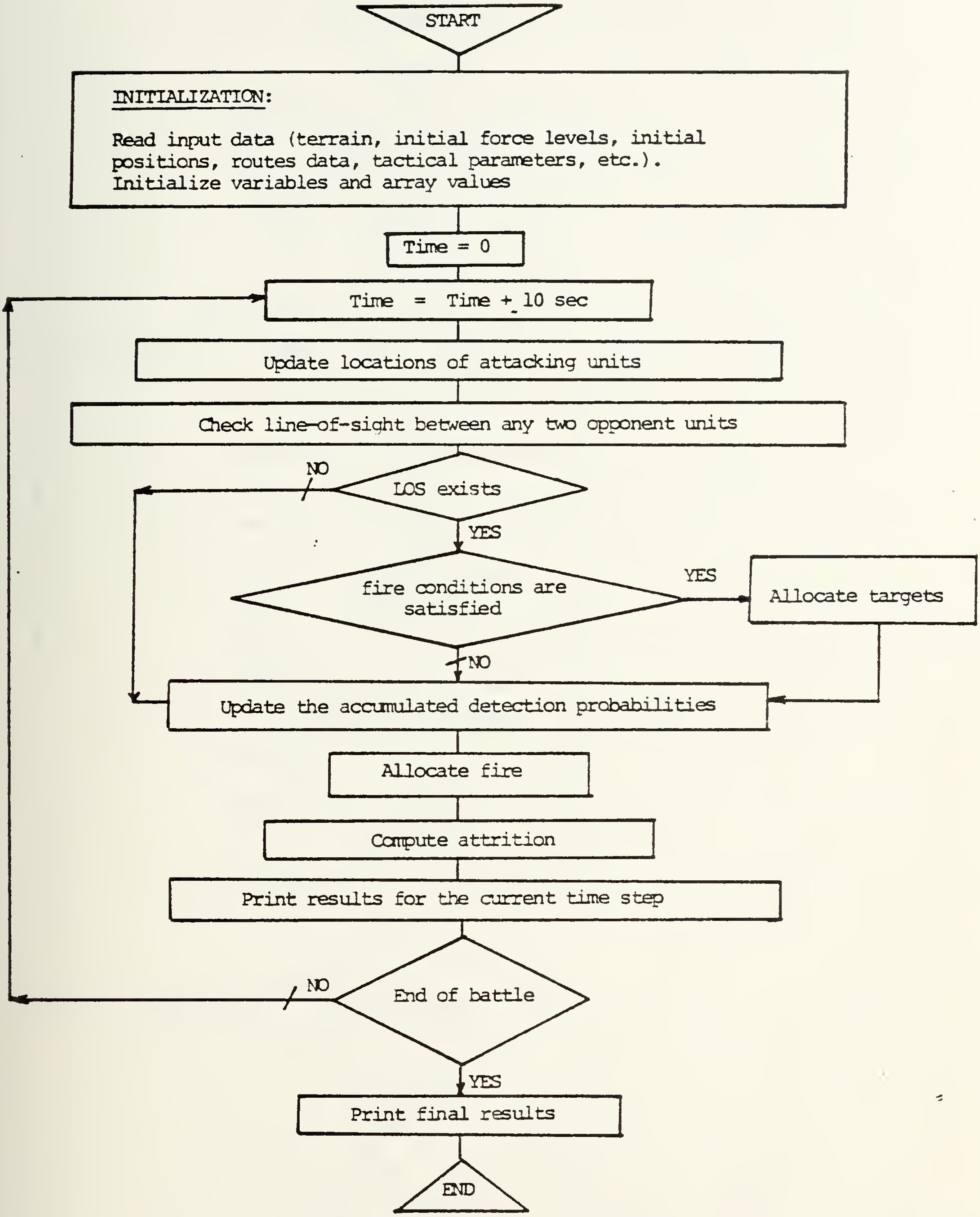
START
INITIALIZATION:
Read input data (terrain, initial force levels, initial positions, routes data, tactical parameters, etc.).
Initialize variables and array values
Time = 0
Time = Time + 10 sec
Update locations of attacking units
Check line-of-sight between any two opponent units
NO
LOS exists
YES
fire conditions are satisfied
YES
Allocate targets
NO
Update the accumulated detection probabilities
Allocate fire
Compute attrition
Print results for the current time step
NO
End of battle
YES
Print final results
END

FIGURE 2. FLOW CHART

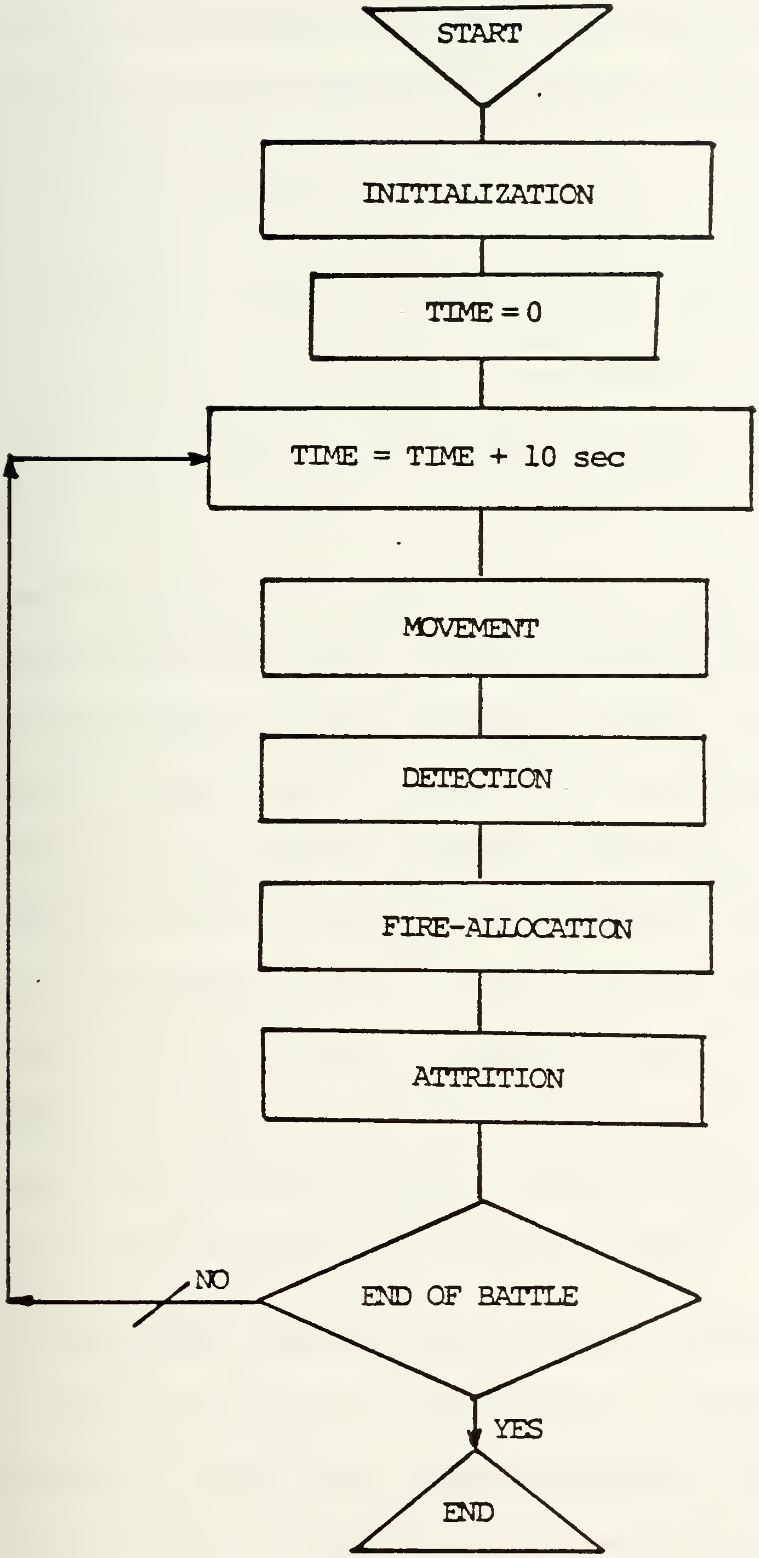

FIGURE 3. GENERAL SCHEME

with the appropriate accumulated probabilities at time t. Basically the accumulation process can be described by the following equation:

$$\begin{aligned} &\Pr(\text{Unit } i \text{ does not detect unit } j \text{ at time } t+\Delta t) \\ &\quad = \Pr(\text{Unit } i \text{ does not detect unit } j \text{ at time } t) \\ &\quad\quad \times \Pr(\text{Unit } i \text{ does not detect unit } j \text{ during } t, t+\Delta t). \end{aligned}$$

The fire allocation phase selects possible targets for every surviving unit, assigns priorities to these targets and determines what fraction of each unit is allocated to fire at each target according to the fire-allocation policy. The attrition phase computes the attrition and the remaining force level for every surviving unit. Since the two forces are homogeneous and use only "aimed-fire", the attrition computation is based on simple Lanchester-type differential equations where the attrition coefficients are computed by the Bonder-Farrel formula. Every such sequence is ended by a battle-termination check process.

B. MOVEMENT PROCESS FOR ATTACKING UNITS

The 3 attacking tank platoons (see R1, R2 and R3 in figure 1) move along 3 predetermined routes. Each route is divided into intervals, 40 meters length each since a non-firing red platoon is assumed to move one such interval during a time step of 10 seconds (i.e., average speed of 9 mph).

Firing red platoon is delayed NOD times before moving to the next interval. Each interval in each route is represented by its center point coordinates and by its direction. If a red platoon enters to an interval along its associated route then it is considered to be positioned only in the center point of this interval (i.e., maximum location error of ±40 since this is the distance between two consecutive intervals).

C. COMMAND AND CONTROL

Command and control are represented in a simple fashion by delaying units which move too fast. If the horizontal distance (along the x-axis) between any two red platoons is more than DISMAX, the leading unit is delayed in order to keep a straight front of the attacking force.

D. LINE-OF-SIGHT (LOS) DETERMINATION

The existence of line-of-sight between any two opposing units is determined in a subroutine called LOS which was written by Prof. James K. Hartman, Naval Postgraduate School. Each hill in the selected piece of terrain is described by a bivariate normal density function and is characterized by the following parameters:

1. Coordinate of the hill center point (xc,yc).
2. Peak height
3. Standard deviatino corresponds to the x-axis (σ_x).
4. Standard deviation corresponds to the y-axis (σ_y).
5. Rotation factor (ρ).

The subroutine is applied by the following FORTRAN statement:

```
CALL LOS(XA,YA,TMACA,TMICA,SIZEA,XB,YB,TMACB,
         TMICB,SIZEB,LATOB,LBTOA,VISFRA,
         VISFRB)
```

where:

XA,YA - coordinate of unit A ($XA, YA \in 0 \div 10{,}000$ m)

TMACA - elevation of unit A (this is found by using the subroutine ELEV(XA,YA,TMACA))

TMICA - depth below ground surface [meters]

SIZEA - height of the vehicle [meters]

$$\text{LATOB} = \begin{cases} 1 & \text{If want LOS with A as observer and B as target} \\ 0 & \text{Else} \end{cases}$$

$$\text{LBTOA} = \begin{cases} 1 & \text{If want LOS with B as observer and A as target} \\ 0 & \text{Else} \end{cases}$$

VISFRA - fraction of A height as seen by B

VISFRB - fraction of B height as seen by A

$0 \leq \text{VISFRA}, \text{VISFRB} \leq 1$

E. DETECTION

1. Types of Detection

A target can be detected in either of two ways: Random search within a designated section of responsibility (non-firing detection) or by launch signature given the target has fired at least one round (firing detection) [Ref. 1].

2. Definitions

Let,

$P_{ij}(t+\Delta t)$ = the probability that unit j is detected by unit i at time t+Δt

We assume:

$$P_{ij}(0) = 0 \quad \forall \; i,j$$

$Q_{ij}(t+\Delta t) = 1 - P_{ij}(t+\Delta t)$ = Probability that unit j is not detected by unit i at time t+Δt

$QV_{ij}(t,\Delta t)$ = Probability that target j is not visually detected (i.e., non-firing detection) by unit i during $[t,t+\Delta t]$ provided that j does not fire during this time interval

$QP_{ij}(t,\Delta t)$ = Probability that target j is not detected by a launch signature during $[t,t+\Delta t]$ provided that j fires during this time interval

3. Computation of $QV_{ij}(t,\Delta t)$

Let

$t_{ij}^{(K)}$ = time for the K^{th} firer of unit i to detect one target of unit j. $K = 1, 2, \ldots, S_i(t)$

where

$S_i(t)$ = number of survivors in unit i at time t.

We assume that $t_{ij}^{(1)}, t_{ij}^{(2)}, \ldots, t_{ij}^{(S_i(t))}$ are independent and identically distributed by $\exp\{\lambda_{ij}\}$ (i.e., exponential distribution with parameter λ_{ij}), where

λ_{ij} = Non-firing detection rate of one target in unit j by one observer in unit i

T_{ij} = the time for unit i to detect one target of unit j

Assuming that all $S_i(t)$ survivors of unit i are searching for a target then

$$T_{ij} = \min\{t_{ij}^{(1)}, t_{ij}^{(2)}, \ldots, t_{ij}^{(S_i(t))}\}$$

and T_{ij} is exponentially distributed with parameter $S_i(t)\lambda_{ij}$ (i.e., $T_{ij} \sim \exp\{S_i(t)\lambda_{ij}\}$]

$QV_{ij}(t,\Delta t)$ = Probability that no one of the $S_i(t)$ survivors of unit j is visually detected by unit i during $[t,t+\Delta t]$

$$= [\Pr(T_{ij} > \Delta t)]^{S_j(t)}$$

$$= [e^{-S_i(t)\lambda_{ij})\Delta t}]^{S_j(t)}$$

or

$$QV_{ij}(t,\Delta t) = e^{-S_i(t)\lambda_{ij}\Delta t S_j(t)}$$

4. Computation of Non-Firing Detection Rate (λ_{ij})

Each firer is assigned to a search section (or section of responsibility) which is characterized by two parameters (see figure 3):

(a) Section width (ISECWD) where $0 \le \text{ISECWD} \le 2\pi$

(b) Primary direction (IPRDIR) where $-\pi \le \text{IPRDIR} \le \pi$

We assume that within the search section the search direction has the following probability density function:

$$f(\theta) = A + B \cos \theta \qquad -D \le \theta \le D$$

where,

$$D = \text{ISECWD}/2$$

$$A = -B \cos D$$

$$B = \frac{1}{2(\sin D - D \cos D)}$$

$\theta = 0$ corresponds to the observer primary direction.

Note: A and B are chosen such that

$$\int_{-D}^{D} f(\theta)d\theta = 1$$

$f(\theta)$ is called the Limicon Function.

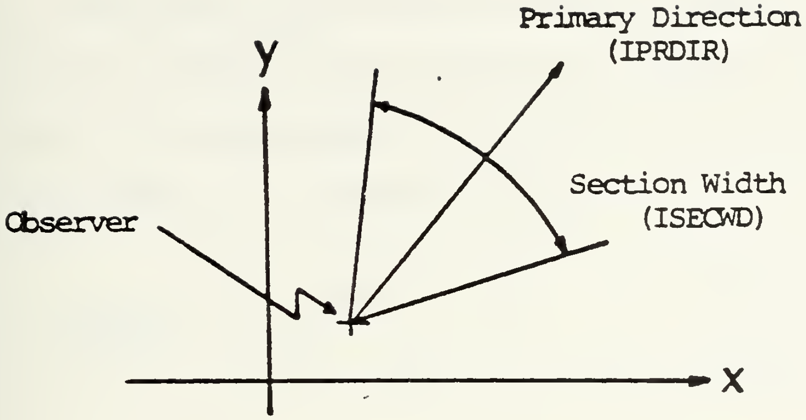

FIGURE 3. SEARCH SECTION

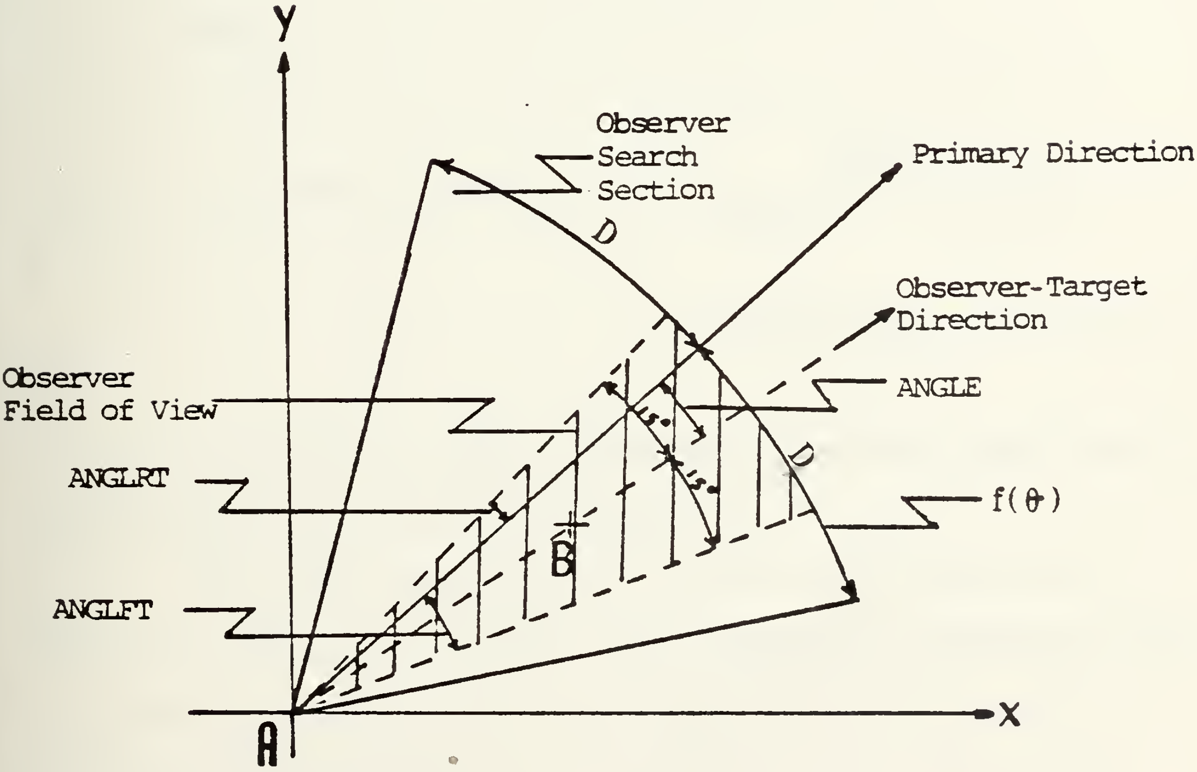

FIGURE 4. OBSERVER-TARGET SCHEME
A = Observer; B = Target

Figure 4 describes the observer-target scheme. Assuming 30° field of view for any observer A target B might be seen only if the observer A is looking at any direction such that ANGRT $\le \alpha \le$ ANGLFT where:

$$\text{ANGLFT} = \begin{cases} \text{ANGLE} + 15^\circ & \text{if ANGLE} + 15^\circ \le D \\ D & \text{if ANGLE} + 15^\circ > D \end{cases}$$

ANGLE = the absolute value of the angle between the primary direction (IPRDIR) and the observer-target direction (OTANG)

ANGRT = ANGLE - 15°

Thus,

$$P_k = \Pr\{\text{ANGRT} \le \alpha \le \text{ANGLFT}\} = \int_{\text{ANGRT}}^{\text{ANGLET}} f(\alpha)\,d\alpha$$

$$= \text{shaded area in figure 4.}$$

P_k is the probability that observer A is looking at direction which enables him to detect target B.

Given that observer A is looking at direction α such that ANGRT $\le \alpha \le$ ANGLFT, the conditional detection rate $\{\lambda_{AB} | \text{ANGRT} \le \alpha \le \text{ANGLFT}\}$ is determined by the following regression curve [Ref. 6]:

$$\{\lambda_{AB} | \text{ANGRT} \leq \alpha \leq \text{ANGLFT}\} = 0.003 + [1.453 + \text{TCFACT} \; (0.5978 + 2.188 \times \text{RR}^2 - 0.5038 \times \text{HORVEL}]^{-1}$$

where,

TCFACT = Terrain factor

HORVEL = Target horizontal velocity [m/sec]

RR = Equivalent range for a full height target [km]

$$= \frac{R}{\text{PCTVIS}} \times \frac{1}{1000}$$

where,

R = The range between A and B

PCTVIS = Height percentage of visibility of target B ($0 \leq \text{PCTVIS} \leq 1$).

The unconditional detection rate (of one observer detecting only one target) is:

$$\lambda_{AB} = \{\lambda_{AB} | \text{ANGRT} \leq \alpha \leq \text{ANGLFT}\} \times P_K$$

λ_{ij} is computed by the subroutine LAMDA using the following FORTRAN statement:

```
CALL LAMDA (I,J,PCTVIS,DETRAT)
```

where the variable DETRAT will contain the detection rate of one target in unit j by one observer in unit i.

5. Computation of $Q_{ij}(t+\Delta t)$

observer does not fire

a. Observer Does Not Fire During $(t,t+\Delta t)$.

(1) Target j does not fire during $(t,t+\Delta t)$.

$$Q_{ij}(t+\Delta t) = Q_{ij}(t) \times QV_{ij}(t,\Delta t)$$

target no firing

[illegible]

where,

$$QV_{ij}(t,\Delta t) = [e^{-S_i(t)\lambda_{ij}^{*}\Delta t}]^{S_j(t)}$$

$$= [e^{-S_i(t)\lambda_{ij}^{*}\Delta t S_j(t)}]$$

where,

$$\lambda_{ij}^{*} = \begin{cases} \lambda_{ij} & \text{if j is a blue unit (stationary)} \\ PM \times \lambda_{ij} & \text{if j is a red unit (moving)} \end{cases}$$

PM = Percent of time that unit i uses for searching targets. $0.0 \leq PM \leq 1.0$

λ_{ij} is computed by the subroutine LAMDA.

(2) Target j fires during $(t,t+\Delta t)$

Let,

$S_i(t)$ = number of survivors in unit i at time t

$S_j(t)$ = number of survivors in unit j at time t

FR_j = fire rate of each weapon system in unit j [rounds per second]

$FR_j \times \Delta t$ = number of rounds fired (at the average) by one firer of unit j during $(t,t+\Delta t)$.

$N = FR_j \times \Delta t \times S_j(t)$ = Total number of rounds fired by unit j during $(t, t+\Delta t)$

Pr{one survivor of unit i to detect unit j by one fire signature} = Pr{survivor looks at direction which enables him to see target j}

x Pr{survivor detects unit j | survivor looks at direction which enables him to see unit j}

$= P_K \times 1.0 = P_K$

Assuming independence, one finds that

Pr{one survivor of unit i does not detect unit j by N fire signatures} $= (1 - P_K)^N$

assuming independence between the survivors of unit i, we find that

Pr{all survivors of unit i doe not detect unit j by a fire signature} $= [(1 - P_K)^N]^{S_i(t)}$

$= (1 - P_K)^{N \times S_i(t)}$

Pr{at least one survivor of unit it detects unit j by a fire signature} $= 1 - (1 - P_K)^{N \times S_i(t)}$

$$QP_{ij}(t,\Delta t) = (1 - P_K)^{NS_i(t)} = (1 - P_K)^{FR_j \Delta t S_j(t) S_i(t)}$$

Now,

$$Q_{ij}(t+\Delta t) = Q_{ij}(t)[QV_{ij}(t,\Delta t) + QP_{ij}(t,\Delta t) - QV_{ij}(t,\Delta t) \times QP_{ij}(t,\Delta t)]$$

where $QV_{ij}(t,\Delta t)$ is computed as described in (1).

b. Observer Fires During $(t,t+\Delta t)$

We assume that if unit i is busy with firing during $(t,t+\Delta t)$ then no targets search is considered by unit i during this time interval. Only units within the field of view of unit i can be detected while unit i is firing. In other words, if unit i fires on unit K then OTANG is the direction of the line from the observer i to the target K and only units within OTANG ± 15° can be detected by unit i (visually or by a fire signature).

(1) Target j fires during $(t,t+\Delta t)$

We define the following event:

A = unit j is within the field of view of unit i with at least one of unit i targets

We assume

$$\Pr\{\text{unit i detects unit j by a fire signature during } (t,t+\Delta t) \mid A\} = 1.0$$

Thus,

$$\Pr\{\text{unit } i \text{ detects unit } j \text{ by a fire signature during } (t,t+\Delta t)\,|\,\bar{A}\} = 0$$

Thus,

$$Q_{ij}(t+\Delta t) = \begin{cases} 0 & \text{if event A occurs} \\ g(n) & \text{if } j \text{ is a Red unit and event } \bar{A} \text{ occurs} \\ Q_{ij}(t) & \text{if } j \text{ is a Blue unit and event } \bar{A} \text{ occurs} \end{cases}$$

where g(n) is an increasing function of n, where n is the number of time intervals elapsed since time t.

$$g(0) = Q_{ij}(t) ,$$

$$Q_{ij}(t) \leq g(n) \leq 1.0 \quad \forall n.$$

(2) Target j does not fire during $(t,t+\Delta t)$

If event A is the same as defined in (1), then

$$Q_{ij}(t+\Delta t) = \begin{cases} Q_{ij}(t) \times QV_{ij}^{*}(t,\Delta t) & \text{if event A occurs} \\ g(n) & \text{if } j \text{ is a Red unit and event } \bar{A} \text{ occurs} \\ Q_{ij}(t) & \text{if } j \text{ is a Blue unit and event } \bar{A} \text{ occurs.} \end{cases}$$

where g(n) is the same as defined in (1) and

$$QV_{ij}^{*}(t,\Delta t) = e^{-S_i^{*}(t)\lambda_{ij}^{*}\Delta t S_j(t)}$$

$\lambda_{ij}^{*} = \lambda_{ij} \times RF$

RF = Reduction factor (the detection rate of unit i has to be reduced since this unit fires during (t,t+ t) and the search for targets is not effective as for a non-firing unit)

$S_i^{*}(t) = S_i(t) \times (\sum_{K \in \mathcal{K}} PTT_{iK})$

PTT_{iK} = proportion of unit i allocated to unit K

$\mathcal{K}$ = {K|Unit K is engaged by unit i and unit j is within the field of view of unit i while observing unit K}

6. Intervisibility Effects on $P_{ij}(t)$

If line-of-sight does not exist between observer i and target j then no accumulation of detection probability takes place during the current time interval (i.e., $P_{ij}(t)$ remains the same). If line-of-sight does not exist during more than 3 consecutive time intervals then $P_{ij}(t)$ is set to zero (i.e., $P_{ij}(t) = 0$) and the accumulation process will start again from zero if line of sight again exists at a later point in the battle.

The motivation for this decision rule is seen by the observation that even if observer i loses line-of-sight

with target j for a short time, he still probably has some idea where to expect the target to appear again.

This decision rule was chosen somewhat arbitrarily, and some other time decreasing function may be employed if desired by the user.

7. Interpretation

$P_{ij}(t)$ can be interpreted as the average fraction of unit i that detects unit j. Any detection that occurs during the n^{th} time interval is used only in the next (i.e., $(n+1)^{st}$) time interval, since that detection represents new knowledge gained during the entire n^{th} interval under the conditions existing in that interval.

F. FIRE ALLOCATION

The first step in a firing event is to determine what fraction of each unit is allocated to fire at each target. Each firing unit does not have to select and fire at just one target. Rather, each firing unit might apportion a fraction of itself against several targets.

1. Selection of Targets

The following conditions are necessary for it to be possible for unit j to be a target of unit i:

(a) Line-of-sight must exist between unit i and unit j.

(b) The range between the two units should be within the interval $[RMIN_i, RMAX_i]$ where the two limits are determined by the weapon system type of unit i and by tactical considerations.

(c) $P_{ij}(t - \Delta t) > 0$.

2. Priority of Targets

Since the two forces are homogenous, the priority of a target is taken to be a function of range only (since (homogeneous type of target is not considered).

3. Fire Allocation Procedure

It will be easier to explain this procedure by numerical example. First, for each unit i we find all the targets j which satisfy the three necessary conditions for being targets (see paragraph 1).

Second, we rank all the targets of unit it by the range.

Let

$$S_i(t) = 100$$

$$RMAX_i = 3000 \text{ m}$$

$$RMIN_i = 500 \text{ m}$$

and assume we have the following situation:

Target (j)	Range	Priority	$P_{ij}(t)$	$\overline{P_{ij}(t)}$
3	750	1	0.2	0.8
1	820	2	0.9	0.1
2	900	3	0.7	0.3

If we allocate fire to each target j as if this target is the only one we have:

Target (j)	Max Allocation = $P_{ij}(t) \times S_i(t)$
3	$P_{i3}(t) \times S_i(t) = .2 \times 100 = 20$
1	$P_{i1}(t) \times S_i(t) = .9 \times 100 = 90$
2	$P_{i2}(t) \times S_i(t) = .7 \times 100 = 70$
	Total: 180

For example, since $P_{i3}(t) = 0.2$ means that 20% of unit i have detected unit j at time t, then not more than 20% of unit i can fire on unit j. Thus, at the maximum not more than $P_{i3}(t) \times S_i(t) = 0.2 \times 100 = 20$ firers out of 100 survivors of unit i can be allocated to fire at unit j. We can obviously see that we need 180 survivors in unit i if we want to allocate fire to each target as if this target is the only one. Since $180 > S_i(t) = 100$ we can't do that. Let us define the following events:

D_j = Target j has been detected by unit i, j = 1,2,3

$\overline{D}_j$ = Target j has not been detected by unit i, j = 1,2,3

If the fire policy is to allocate 100% of the firepower of unit i to the most prior target then we have:

Situation	Probability	Engaged Target
$\bar{D}_1 \cap \bar{D}_2 \cap \bar{D}_3$	0.1 x 0.3 x 0.8 = 0.024	-
$D_1 \cap \bar{D}_2 \cap \bar{D}_3$	0.9 x 0.3 x 0.8 = 0.216	1
$\bar{D}_1 \cap D_2 \cap \bar{D}_3$	0.1 x 0.3 x 0.8 = 0.056	2
$\bar{D}_1 \cap \bar{D}_2 \cap D_3$	0.1 x 0.3 x 0.2 = 0.006	3
$D_1 \cap \cancel{\bar{D}}_2 \cap \bar{D}_3$	0.9 x 0.7 x 0.8 = 0.504	1
$D_1 \cap \bar{D}_2 \cap D_3$	0.9 x 0.3 x 0.2 = 0.054	3
$\bar{D}_1 \cap D_2 \cap D_3$	0.1 x 0.7 x 0.2 = 0.014	3
$D_1 \cap D_2 \cap D_3$	0.9 x 0.7 x 0.2 = 0.126	3

The fire distribution is:

$$\Pr\{\text{Target 1 will be engaged}\} = 0.216 + 0.504 = 0.72$$

$$\Pr\{\text{Target 2 will be engaged}\} = 0.056$$

$$\Pr\{\text{Target 3 will be engaged}\} = 0.20$$

Thus, if the same battle is repeated many times then in 72% of the times all the $S_i(t) = 100$ survivors of unit i are allocated to target 1, in 5.6% of the times to target 2 and in 20% of the times to target 3.

If the fire policy is as follows:

# of targets	% of unit i allocated to each target		
	1st	2nd	3rd
1	100%		
2	80%	20%	
3	80%	15%	5%

then we have,

Situation	Probability	Allocation		
		tgt 1	tgt 2	tgt 3
$\bar{D}_1 \cap \bar{D}_2 \cap \bar{D}_3$	0.024	-	-	-
$D_1 \cap \bar{D}_2 \cap \bar{D}_3$	0.216	100%	-	-
$\bar{D}_1 \cap D_2 \cap \bar{D}_3$	0.056	-	100%	-
$\bar{D}_1 \cap \bar{D}_2 \cap D_3$	0.006	-	-	100%
$D_1 \cap D_2 \cap \bar{D}_3$	0.504	80%	20%	-
$D_1 \cap \bar{D}_2 \cap D_3$	0.054	20%	-	80%
$\bar{D}_1 \cap D_2 \cap D_3$	0.014	-	20%	80%
$D_1 \cap D_2 \cap D_3$	0.126	15%	5%	80%

$$E[\text{percent of fire of unit } i \text{ allocated to target 1}] = 100 \times 0.216 + 80 \times 0.504 + 20 \times 0.054 + 15 \times 0.126 = \underline{64.89}$$

$$E[\text{percent of fire of unit } i \text{ allocated to target } 2] = 100 \times 0.056 + 20 \times 0.504 + 20 \times 0.014 + 5 \times 0.126$$

$$= \underline{16.59}$$

$$E[\text{percent of fire of unit } i \text{ allocated to target } 3] = 100 \times 0.006 + 80 \times 0.054 + 80 \times 0.014 + 80 \times 0.126$$

$$= \underline{16.12}$$

If we compare the two fire policies we have,

	Tgt 1	Tgt 2	Tgt 3	Total
Policy I	72%	5.6%	20%	97.6%
Policy II	64.89%	16.59%	16.12%	97.6%

Comments:

(1) The big change of fire allocation to target 2 is explained by the fact that situation 5 (i.e., $\overline{D}_1 \cap D_2 \cap \overline{D}_3$) has high probability of occurrence (0.504) and 20 firers of unit i are allocated to target 2 in this case.

(2) In both cases only 97.6 firers of unit i are allocated since there is a positive probability of not detecting all the three targets (i.e., positive probability for $\overline{D}_1 \cap \overline{D}_2 \cap \overline{D}_3$) and in this case no fire is allocated at all.

(3) This method gets more complicated as the number of targets becomes larger.

G. ATTRITION

Since the two forces (i.e., attacker and defender) are taken to use only "aimed" fire, variable coefficient Lanchester-type equations of modern warfare [see Ref. 2] are used to assess force-on-force attrition. For each time interval $[t, t+\Delta t]$ let,

$S_i(t)$ = number of survivors in unit i at time t

B_i = the group of Blue units who fire against unit i

R_j = the group of Red units who fire against unit j

A_{ij} = the rate at which one firer of unit i kills unit j targets. (Attrition rate of unit j by one firer of unit i)

$PROP_{ij}$ = proportion of unit i allocated to fire against unit j.

These parameters are computed for each time interval. The attrition-rate coefficient A_{ij} is computed according to

$$A_{ij} = \frac{1}{E(T_{ij})},$$

where T_{ij} is the time for one firer of unit i to kill one target of unit j under the conditions existing in this time interval. $E(T_{ij})$ is computed by the Bonder-Farrell formula (see Ref. 7):

$$E(T_{ij}) = t_a + t_1 - t_h + \frac{t_h + t_f}{P(K|H)} + \frac{t_m + t_f}{P(h|m)} \times \left\{ \frac{1 - P(h|h)}{P(K|H)} + P(h|h) - p \right\} \qquad (1)$$

where,

t_a = time to acquire a target,

t_1 = time to fire first round after target acquired,

t_h = time to fire a round following a hit,

t_m = time to fire a round following a miss,

t_f = projectile time of flight,

P = Probability of hit on first round,

$P(h|h)$ = Probability of a hit on a round following a hit,

$P(h|m)$ = Probability of a hit on a round following a miss,

$P(K|H)$ = Probability of destroying a target given it is hit.

This formula (1) holds for the following conditions:

(1) Markov-dependent fire with parameters P, $P(h|h)$ and $P(h|m)$. (I.e., Hit probability of any round depends only on the result of the previous round.)

(2) Geometric distribution for the number of hits required for a kill with parameter $P(K|H)$ (i.e., accumulated damage is not considered!).

If the firing weapon system is TOW then we assume $P(K|H) = 1.0$ and $p(h|m) = p(h|h) = p$. In this case we have

$$E(T_{ij}) = t_a + t_l + t_f + \frac{(t_m + t_f)(1-p)}{p}$$

If the firing weapon system is a tank then we assume $P(K|H) = 1.0$ (because of lack of information) and $t_f \simeq 0$. In this case we have:

$$E(T_{ij}) = t_a + t_l + \frac{t_m}{p(h|m)}\{1 - p\} ,$$

The attrition of each Blue unit j is described by the following differential equation:

$$\frac{dS_j(t)}{dt} = - \sum_{i \varepsilon R_j} A_{ij}(S_i(t) \times PROP_{ij})$$

and similarly the attrition of each Red unit i is described by:

$$\frac{dS_i(t)}{dt} = - \sum_{j \varepsilon B_i} A_{ji}(S_j(t) \times PROP_{ji})$$

where the attrition coefficients A_{ij} and A_{ji} are computed by Bonder-Farrell's model.

The basic differential equations of force-on-force attrition are approximated by the following Euler-Cauchy difference equations:

$$S_i(t+\Delta t) = \text{Max}\{0, S_i(t) - \sum A_{ji}(S_j(t) \times \text{PROP}_{ji})\Delta t\}$$

For each Blue unit i

$$S_j(t+\Delta t) = \text{Max}\{0, S_j(t) - \sum_{i \varepsilon B_j} A_{ij}(S_i(t) \times \text{PROP}_{ij}\Delta t\}$$

For each Red unit j

COMMENTS:

(1) While computing attrition in a given scenario we can consider all the targets as stationary since the defender is in fixed positions and since the hit probability of a TOW against moving target is almost the same as for stationary (given that the target is not too close). Thus also the Red units can be considered as stationary for attrition computation purposes.

(2) This attrition model does not consider the problem of intervisibility "windows" for the TOW.

(3) Hit probabilities as $P(h|h)$ and $P(h|m)$ are functions of: size of the target (full target or turret target), type of ammunition (HGAT or APFSDS), Range, angle between the firer and the target etc. Since most of this information is classified only full size targets,

APFSDS ammunition (for tanks) and the range were considered while running the program in the computer.

(4) Artillary is not considered in this model. One should remember that artillary reduces very drastically the TOW hit probability (but not too much the tank's hit probability).

H. BATTLE-TERMINATION PROCESS

The breakpoint for each unit is 100% lost of its initial force level. The battle is terminated when either:

1. One of the two opponent forces (i.e., Red or Blue) is annihilated (i.e., its 3 platoons have reached the breakpoint).
2. The average distance between the surviving Red force and the surviving Blue force is "too close."

IV. SENSITIVITY ANALYSIS

Sensitivity study was done without considering the line-of-sight factor (i.e., it was assumed that line-of-sight exists all the time) in order to make the battle more active (i.e., fights are more frequent and more units are involved in every one of them) and thus more sensitive to most of the parameters.

A. FIRE ALLOCATION POLICY

Three fire allocation policies were tested:

Policy	1 Target	2 targets		3 targets		
		1st	2nd	1st	2nd	3rd
1	100%	100%	-	100%	-	-
2	100%	80%	20%	80%	15%	5%
3	100%	50%	50%	33.3%	33.3%	33.3%

Table 1. Fire Allocation Policies

Appendix C describes the output for three battles corresponding to the three different fire allocation policies. Table 2 summarizes the main events in each battle for comparison purposes.

EVENT	Policy 3				Policy 2				Policy 1			
	UD	T	RTL	BTL	UD	T	RTL	BTL	UD	T	RTL	BTL
1	6	40	0.131	0.333	6	40	0.131	0.333	6	40	0.128	0.333
2	1	140	0.472	0.444	1	150	0.484	0.503	1	150	0.464	0.517
3	2	210	0.710	0.508	4	240	0.623	0.667	4	210	0.557	0.667
4	4	300	0.837	0.667	3	410	0.864	0.712	3	390	0.760	0.714
5	3	440	1.00	0.68	2	440	1.00	0.723	2	440	1.00	0.759

Table 2. Fire Allocation Sensitivity

where,

EVENT occurs when a unit is destroyed

UD = The number of the destroyed unit

T = time (sec)

RTL = Red total lost (percentage)

BTL = Blue total lost (percentage)

The conclusions drawn from these results are:

a. Policy 3 should be prefered to the Blue force since its total lost is consistently smaller when it uses this policy.

b. Policy 1 should be prefered by the Red force for the same reasons.

c. These conclusions are appropriate only for the given scenario and they might be different for other scenarios.

d. The differences are relatively small but they might be larger for different scenarios (i.e., different force structure, weapon characteristics, etc.).

e. In this sensitivity study the same fire allocation policies were tested for both sides. Future work might be done to test different policies for the two forces.

B. MOVEMENT DELAY OF A FIRING UNIT

A firing Red unit is delayed NOD time intervals before moving to the next route interval.

A sensitivity study of this parameter was done for NOD = 2, 3, 4, 5, 6, 8. Table 3 describes the results of this study. Table 4 shows the sensitivity of battle termination time to the parameter NOD. One can see that a change from NOD = 2 to NOD = 6 extends the battle time by more than 25%. No change is caused by changing NOD from 6 to 8. Table 5 shows the sensitivity of Blue total lost (fraction of initial strength) to changes in NOD. No significant change is caused to this variable by changing the value of NOD from 2 to 4. A change of 6% is caused by changing NOD from 4 to 5 and 8% by changing NOD from 4 to 6. We can also see that from NOD = 5 and further on the event's sequence is changed although the final results are not significantly changed.

NOD = 2			NOD = 3			NOD = 4			NOD = 5			NOD = 6			NOD = 8		
TD	T	LOC	TD	T	LOC	TD	T	LOC	TD	T	LOC	TD	T	LOC	TD	T	LOC
6	40	F	6	40	F	6	40	F	6	40	F	6	40	F	6	40	F
1	150	11	1	150	10	1	150	9	1	150	9	1	150	8	1	150	8
4	220	F	4	240	F	4	250	F	2	260	14	2	240	13	2	240	13
3	380	33	3	410	33	3	440	33	4	330	F	4	430	F	4	430	F
2	410	33	2	440	33	2	460	32	3	480	32	3	550	32	3	550	32
RTL = 1.0			RTL = 1.0			RTL = 1.0			RTL = 1.0			RTL = 1.0			RTL = 1.0		
BTL = 0.726			BTL = 0.723			BTL = 0.724			BTL = 0.682			BTL = 0.667			BTL = 0.667		

TD = TARGET DESTROYEE

T = TIME

LOC = LOCATION

RTL = RED TOTAL LOST (fraction of original strength)
BTL = BLUE TOTAL LOST (Fraction of original strength)

F = FIXED POSITION

TABLE 3. NOD SENSITIVITY ANALYSIS

NOD	Battle Termination Time (sec)
2	410
3	440
4	460
5	480
6	550
8	550

Table 4. NOD VS BATTLE TERMINATION TIME

NOD	Blue Total Lost
2	0.726
3	0.723
4	0.724
5	0.682
6	0.667
8	0.667

Table 5. NOD VS BLUE TOTAL LOST

C. DETECTION RATE REDUCTION OF A FIRING UNIT

The detection rate of a firing unit is reduced by a multiplicative factor RF ($0.0 \leq RF \leq 1.0$) in comparison to that of a non-firing unit. This is done, since it is hypothesized that the search effectiveness is not the same in both cases. The sensitivity of results to changes in this parameter (RF) was done for RF = 0.2, 0.3, 0.4, 0.5, 0.6, 0.8. It was found that the battle outcomes are not significantly sensitive to changes in the RF parameter.

D. OBSERVATION TIME PROPORTION OF A MOVING UNIT

The parameter PM is defined as the proportion of time a moving unit spends for targets search. Sensitivity study of this parameter (PM) was done for PM = 0.15, 0.25, 0.35, 0.45, 0.55.

It was found that the battle outcomes are not significantly sensitive to changes in the PM parameter.

V. FUTURE MODEL ENHANCEMENT AND UTILIZATION

A. FUTURE ENHANCEMENT AREAS

The following additions or improvements in the model are recommended:

1. Addition of artillery to both sides. Artillery has significant suppression effects on the TOWs.
2. Addition of information (target acquisition) handoff from one unit to another.
3. Addition of ability to play minefield and barriers.
4. Addition of the effects of close air support.
5. Modification to the interactive mode.

In such a mode tactical decisions (e.g., route selection) could be input by players as the battle evolves. Additionally, some more predetermined alternative routes and alternative fire allocation policies can be programmed. In this case, the players of both sides (company or platoon commanders) can decide after each time interval which tactic of fire allocation to use, which route to choose and to ask for artillery or close air support (with appropriate amount of delay).

B. UTILIZATION

The model with the additional recommended improvements might be used as a tool for tactical training (battalion, company and platoon leaders) or tactical planning (effect

of different structure of forces or units, types of weapon systems, fire allocation policies, minimum or maximum ranges of fire, etc.) at the battalion level.

APPENDIX A

PROGRAM LISTING

```
      COMMON /GRP1/ IPRDIR(6),ISECWD(6),MVTDIR(6),X(6),Y(6),SPD(6)      THE00010
      COMMON /GRP2/ TA(2),T1(2),TH(2),TM(2),TF1(2),TF2(2),TF3(2),       THE00020
     1P(2,6),PHH(2,6),PHM(2,6),PKH(2,6),TF(2)                           THE00030
      COMMON /GRP3/ NBU,NRU,FL(6),FO(6),NOI(3),XIC(3,100),YIC(3,100),   THE00040
     1IDIR(3,100),AVSP                                                  THE00050
     1,IUSTAT(6),II(6),LOST(6,6),VISFRA,VISFRB,SIZETK,                  THE00060
     1SIZETW,NT(6),NF(6),SRF,DISMAX,                                    THE00070
     1NLOSC(6,6),VISFP(6,6),RMINTK,RMXTK,RMINTW,RMXTW,OP,TOWFR,TNKFR,   THE00080
     1PTT(3,3),RF,POA(6,6),APOA(6,6),LOA(6,6),NA(6),OFL(6),POL(6)       THE00090
      COMMON /GRP4/ TPOL(6),OLDQ(6,6),Q(6,6)                            THE00100
      COMMON /GRP5/ LOT(6,6),ROT(6,6)                                   THE00110
      COMMON /HILLS/ XC(100),YC(100),PEAK(100),SX(100),SY(100),RHO(100) THE00120
      COMMON /HILLS/ SCALE(100),TWORHO(100),TWOSCL(100),BASE            THE00130
      COMMON /HILLS/ NHILLS                                             THE00140
      COMMON /COVER/ CXC(150),CYC(150),CPEAK(150),CPXX(150),CPYY(150)   THE00150
      COMMON /COVER/ CPXY(150),NCVELS                                   THE00160
      COMMON /COUNTR/ KH,KHW,KV,KN,KGRS,KELL,KINT                       THE00170
      COMMON /GRID/ LST(10,10),NHL(10,10),LISTH(450),KHREP(100),KTREP   THE00180
      COMMON /GRID/ LSTC(10,10),NC(10,10),LISTC(400),KCREP(150)         THE00190
C                                                                       THE00200
C                                                                       THE00210
C                                                                       THE00220
C                                                                       THE00230
C     INITIALIZATION.                                                   THE00240
C                                                                       THE00250
C                                                                       THE00260
C                                                                       THE00270
      MP=0                                                              THE00280
      PAI=22.0/7.0                                                      THE00290
      ZL=0.00001                                                        THE00300
      CALL SETUP                                                        THE00310
C      A SUBROUTINE TO READ THE TERRAIN DATA FOR THE LINE-OF-SIGHT      THE00320
C     SUBROUTINE.                                                       THE00330
      READ(5,100)NBU,NRU,AVSP,SIZETK,SIZETW,RMINTK,RMXTK,RMINTW,        THE00340
     1RMXTW                                                             THE00350
  100 FORMAT(I2,1X,I2,1X,F4.1,1X,F4.2,1X,F4.2,1X,F6.1,1X,F6.1,1X,F6.1,1XTHE00360
     1,F6.1)                                                            THE00370
      WRITE(6,164)NBU,NRU,AVSP,SIZETK,SIZETW,RMINTK,RMXTK,RMINTW,       THE00380
     1RMXTW                                                             THE00390
  164 FORMAT(1X,'NBU=',I1,1X,'NRU=',I1,1X,'AVSP=',F4.1,1X,'SIZETK=',    THE00400
     1F4.2,1X,'SIZETW=',F4.2,1X,'RMINTK=',F6.1,1X,'RMXTK=',F6.1,1X,     THE00410
     1'RMINTW=',F6.1,1X,'RMXTW=',F6.1)                                  THE00420
      READ(5,120)PM,RF,TOWFR,TNKFR,NOD                                  THE00430
  120 FORMAT(F5.3,1X,F5.3,1X,F5.3,1X,F5.3,1X,I1)                        THE00440
      WRITE(6,165)PM,RF,TOWFR,TNKFR,NOD                                 THE00450
  165 FORMAT(1X,'PM=',F5.3,1X,'RF=',F5.3,1X,'TOWFR=',F5.3,1X,           THE00460
     1'TNKFR=',F5.3,1X,'NOD=',I1)                                       THE00470
      K=NRU+1                                                           THE00480
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      L=NRU+NBU                                                         THE00490
      READ(5,101)(NOI(I),I=1,3)                                         THE00500
  101 FORMAT(3(I3,1X))                                                  THE00510
      YY=6500.0                                                         THE00520
      DO 2 I=1,3                                                        THE00530
      K20=NOI(I)                                                        THE00540
      XX=5000.0                                                         THE00550
      YY=YY-500.0                                                       THE00560
      DO 2 J=1,K20                                                      THE00570
      XIC(I,J)=XX+(J-1)*40.0                                            THE00580
      YIC(I,J)=YY                                                       THE00590
      IDIR(I,J)=0                                                       THE00600
    2 CONTINUE                                                          THE00610
      SUMRO=0.0                                                         THE00620
      DO 3 I=1,NRU                                                      THE00630
      READ(5,103)FL(I)                                                  THE00640
  103 FORMAT(F6.3)                                                      THE00650
      FO(I)=FL(I)                                                       THE00660
      SUMRO=SUMRO+FO(I)                                                 THE00670
      X(I)=XIC(I,1)                                                     THE00680
      Y(I)=YIC(I,1)                                                     THE00690
      MVTDIR(I)=IDIR(I,1)                                               THE00700
      SPD(I)=AVSP                                                       THE00710
      IUSTAT(I)=0                                                       THE00720
      IPRDIR(I)=IDIR(I,1)                                               THE00730
      ISECWD(I)=120                                                     THE00740
      NF(I)=0                                                           THE00750
      II(I)=1                                                           THE00760
    3 CONTINUE                                                          THE00770
      SUMBO=0.0                                                         THE00780
      DO 4 I=K,L                                                        THE00790
      READ(5,104)X(I),Y(I),FL(I),IPRDIR(I),ISECWD(I)                    THE00800
  104 FORMAT(F9.3,1X,F9.3,1X,F6.3,1X,I3,1X,I3)                          THE00810
      FO(I)=FL(I)                                                       THE00820
      SUMBO=SUMBO+FO(I)                                                 THE00830
      MVTDIR(I)=0                                                       THE00840
      SPD(I)=0.0                                                        THE00850
      IUSTAT(I)=0                                                       THE00860
    4 CONTINUE                                                          THE00870
      DO 85 I=1,L                                                       THE00880
      WRITE(6,169)I,FL(I),X(I),Y(I),IPRDIR(I),ISECWD(I),MVTDIR(I),      THE00890
     1SPD(I),IUSTAT(I)                                                  THE00900
  169 FORMAT(1X,'I=',I1,1X,'FL(I)=',F6.3,1X,'X(I)=',F9.3,1X,'Y(I)=',    THE00910
     1F9.3,1X,'IPRDIR(I)=',I3,                                          THE00920
     11X,'ISECWD(I)=',I3,1X,'MVTDIR(I)=',I3,1X,'SPD(I)=',               THE00930
     1F4.1,1X,'IUSTAT(I)=',I1)                                          THE00940
   85 CONTINUE                                                          THE00950
      DELT=10.0                                                         THE00960
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ol<38h

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      DO 5  I=1,2                                                       THE00970
      READ(5,105)TA(I),T1(I),TH(I),TM(I),TF1(I),TF2(I),TF3(I)           THE00980
  105 FORMAT( 7(F4.1,1X))                                               THE00990
      DO 514  J=1,6                                                     THE01000
      READ(5,515)P(I,J),PHH(I,J),PHM(I,J),PKH(I,J)                      THE01010
  515 FORMAT(4(F5.3,1X))                                                THE01020
  514 CONTINUE                                                          THE01030
    5 CONTINUE                                                          THE01040
      PTT(1,1)=1.0                                                      THE01050
      PTT(1,2)=0.8                                                      THE01060
      PTT(2,2)=0.2                                                      THE01070
      PTT(1,3)=0.8                                                      THE01080
      PTT(2,3)=0.15                                                     THE01090
      PTT(3,3)=0.05                                                     THE01100
      WRITE(6,518)PTT(1,1),PTT(1,2),PTT(2,2),PTT(1,3),PTT(2,3),PTT(3,3) THE01110
  518 FORMAT(1X,'PTT(1,1)=',F5.3,1X,'PTT(1,2)=',F5.3,1X,'PTT(2,2)=',    THE01120
     1F5.3,1X,'PTT(1,3)=',F5.3,1X,'PTT(2,3)=',F5.3,1X,'PTT(3,3)=',      THE01130
     1F5.3)                                                             THE01140
      DO 31 I=1,NRU                                                     THE01150
      DO 31  J=K,L                                                      THE01160
      NLOSC(I,J)=0                                                      THE01170
      NLOSC(J,I)=0                                                      THE01180
      Q(I,J)=1.0                                                        THE01190
      Q(J,I)=1.0                                                        THE01200
      VISFR(I,J)=0.0                                                    THE01210
      VISFR(J,I)=0.0                                                    THE01220
   31 CONTINUE                                                          THE01230
      IC=1                                                              THE01240
C                                                                       THE01250
C                                                                       THE01260
C                                                                       THE01270
C     UPDATE LOCATION OF RED UNITS.                                     THE01280
C                                                                       THE01290
C                                                                       THE01300
C                                                                       THE01310
      DISMAX=150.0                                                      THE01320
   67 DO 9 I=1,NRU                                                      THE01330
      IF(IUSTAT(I).EQ.2) GOTO 9                                         THE01340
      IF(IUSTAT(I).EQ.0) GOTO 76                                        THE01350
      NF(I)=NF(I)+1                                                     THE01360
      IF(NF(I).LT.NOD) GOTO 9                                           THE01370
      NF(I)=0                                                           THE01380
   76 II(I)=II(I)+1                                                     THE01390
      K7=II(I)                                                          THE01400
      X(I)=XIC(I,K7)                                                    THE01410
      Y(I)=YIC(I,K7)                                                    THE01420
      MVTDIR(I)=IDIR(I,K7)                                              THE01430
      IPRDIR(I)=IDIR(I,K7)                                              THE01440
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    9 CONTINUE                                                      THE01450
      K9=NRU-1                                                      THE01460
      DO 10 I=1,K9                                                  THE01470
      IF(IUSTAT(I).EQ.2) GOTO 10                                    THE01480
      K8=I+1                                                        THE01490
      DO 11 J=K8,NRU                                                THE01500
      IF(IUSTAT(J).EQ.2) GOTO 11                                    THE01510
      DIST=X(I)-X(J)                                                THE01520
      IF(ABS(DIST).LE.DISMAX) GOTO 11                               THE01530
      IF(DIST.GT.ZL) GOTO 50                                        THE01540
      I3=J                                                          THE01550
   51 II(I3)=II(I3)-1                                               THE01560
      K7=II(I3)                                                     THE01570
      X(I3)=XIC(I3,K7)                                              THE01580
      Y(I3)=YIC(I3,K7)                                              THE01590
      MVTDIR(I3)=IDIR(I3,K7)                                        THE01600
      IPRDIR(I3)=IDIR(I3,K7)                                        THE01610
      GOTO 11                                                       THE01620
   50 I3=I                                                          THE01630
      GOTO 51                                                       THE01640
   11 CONTINUE                                                      THE01650
   10 CONTINUE                                                      THE01660
C                                                                   THE01670
C                                                                   THE01680
C                                                                   THE01690
C                                                                   THE01700
C     LINE--OF-SIGHT CHECK BETWEEN UNITS AND TARGETS SELECTION      THE01710
C                                                                   THE01720
C                                                                   THE01730
C                                                                   THE01740
C                                                                   THE01750
      DO 17 J=K,L                                                   THE01760
      NT(J)=0                                                       THE01770
   17 CONTINUE                                                      THE01780
      DO 12 I=1,NRU                                                 THE01790
      NT(I)=0                                                       THE01800
      IF(IUSTAT(I).EQ.2) GOTO 12                                    THE01810
      DO 16 J=K,L                                                   THE01820
      IF(IUSTAT(J).EQ.2) GOTO 16                                    THE01830
      XX1=X(I)                                                      THE01840
      YY1=Y(I)                                                      THE01850
  133 CALL ELEV(XX1,YY1,TMACI)                                      THE01860
      XX2=X(J)                                                      THE01870
      YY2=Y(J)                                                      THE01880
      CALL ELEV(XX2,YY2,TMACJ)                                      THE01890
      LATOB=1                                                       THE01900
      LBTOA=1                                                       THE01910
      CALL LOS(XX1,YY1,TMACI,0.0,SIZETK,XX2,YY2,TMACJ,0.0,SIZETW,   THE01920
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     1LATOB,LBTOA,VISFRA,VISFRB)                                        THE01930
      VISFRA=1.0                                                        THE01940
      VISFRB=1.0                                                        THE01950
      VISFR(I,J)=VISFRA                                                 THE01960
      VISFR(J,I)=VISFRB                                                 THE01970
      IF(VISFRA.GT.ZL)  GOTO 18                                         THE01980
      LOST(I,J)=0                                                       THE01990
      LOST(J,I)=0                                                       THE02000
      NLOSC(I,J)=NLOSC(I,J)+1                                           THE02010
      NLOSC(J,I)=NLOSC(I,J)                                             THE02020
      GOTO 16                                                           THE02030
   18 LOST(I,J)=1                                                       THE02040
      LOST(J,I)=1                                                       THE02050
      NLOSC(I,J)=0                                                      THE02060
      NLOSC(J,I)=0                                                      THE02070
      RANGE=SQRT((X(I)-X(J))**2+(Y(I)-Y(J))**2)                         THE02080
      IF(RANGE.LT.RMINTK.OR.RANGE.GT.RMXTK)GOTO 20                      THE02090
      IF(Q(I,J).EQ.1.0)  GOTO 20                                        THE02100
      IUSTAT(I)=1                                                       THE02110
      NT(I)=NT(I)+1                                                     THE02120
      M=NT(I)                                                           THE02130
      LOT(I,M)=J                                                        THE02140
      ROT(I,M)=RANGE                                                    THE02150
      IF(M.EQ.1)  GOTO  20                                              THE02160
      CALL  SORT(I,M)                                                   THE02170
   20 IF(RANGE.LT.RMINTW.OR.RANGE.GT.RMXTW)  GOTO 16                    THE02180
      IF(Q(J,I).EQ.1.0)  GOTO 16                                        THE02190
      IUSTAT(J)=1                                                       THE02200
      NT(J)=NT(J)+1                                                     THE02210
      M=NT(J)                                                           THE02220
      LOT(J,M)=I                                                        THE02230
      ROT(J,M)=RANGE                                                    THE02240
      IF(M.EQ.1)  GOTO 16                                               THE02250
      CALL  SORT(J,M)                                                   THE02260
   16 CONTINUE                                                          THE02270
   12 CONTINUE                                                          THE02280
      DO  25  I=1,NRU                                                   THE02290
      IF(IUSTAT(I).EQ.2)  GOTO  25                                      THE02300
      IF(NT(I).NE.0)  GOTO 25                                           THE02310
      IUSTAT(I)=0                                                       THE02320
      NF(I)=0                                                           THE02330
   25 CONTINUE                                                          THE02340
      DO  79  J=K,L                                                     THE02350
      IF(IUSTAT(J).EQ.2)  GOTO 79                                       THE02360
      IF(NT(J).EQ.0)  IUSTAT(J)=0                                       THE02370
   79 CONTINUE                                                          THE02380
C                                                                       THE02390
C                                                                       THE02400
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C                                                                       THE02410
C                                                                       THE02420
C                                                                       THE02430
C     UPDATE OF THE ACCUMULATED DETECTICN PROBABILITIES.                THE02440
C                                                                       THE02450
C                                                                       THE02460
C                                                                       THE02470
C                                                                       THE02480
      IAA=1                                                             THE02490
      IBB=NRU                                                           THE02500
      ICC=K                                                             THE02510
      IDD=L                                                             THE02520
      FR=TOWFR                                                          THE02530
      OP=PM                                                             THE02540
   37 DO 14 I=IAA,IBB                                                   THE02550
      IF(IUSTAT(I).EQ.2) GOTO 14                                        THE02560
      DC 19 J=ICC,IDD                                                   THE02570
      PROP=0.0                                                          THE02580
      IF(IUSTAT(J).EQ.2) GOTO 19                                        THE02590
      OLDQ(I,J)=Q(I,J)                                                  THE02600
      IF(LOST(I,J).EQ.0) GOTO 15                                        THE02610
      IF(NT(I).GT.0) GOTO 22                                            THE02620
      PCTVIS=VISFR(J,I)                                                 THE02630
      CALL LAMDA(I,J,PCTVIS,DETRAT,PSUBK)                               THE02640
      QV=EXP(-(FL(I)*DETRAT*OP*DELT*FL(J)))                             THE02650
      IF(NT(J).GT.0) GOTC 23                                            THE02660
      Q(I,J)=Q(I,J)*QV                                                  THE02670
      GCTO 19                                                           THE02680
   23 QP=(1.0-PSUBK)**(FR*DELT*FL(I)*FL(J))                             THE02690
      Q(I,J)=Q(I,J)*(QV+QP-QV*QP)                                       THE02700
      GCTO 19                                                           THE02710
   22 N5=NT(I)                                                          THE02720
      DO 24 I1=1,N5                                                     THE02730
      K1=LOT(I,I1)                                                      THE02740
      ANG1=ATAN2(Y(K1)-Y(I),X(K1)-X(I))                                 THE02750
      ANG2=ATAN2(Y(J)-Y(I),X(J)-X(I))                                   THE02760
      IF((ANG1*ANG2).GE.0.0) GOTO 77                                    THE02770
      IF(ANG2.LT.0.0) GOTO 32                                           THE02780
      ANG=2*PAI+ANG1-ANG2                                               THE02790
      GOTO 35                                                           THE02800
   32 ANG=2*PAI+ANG2-ANG1                                               THE02810
   35 IF(ANG.GT.PAI) ANG=2*PAI-ANG                                      THE02820
      GOTO 33                                                           THE02830
   77 ANG=ABS(ANG2-ANG1)                                                THE02840
   33 AA=15.0*PAI/180.0                                                 THE02850
      IF(ANG.GT.AA) GOTO 24                                             THE02860
      PRCP=PRCP+PTT(I1,N5)                                              THE02870
   24 CONTINUE                                                          THE02880
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      IF(PROP.EQ.0.0) GOTO 34                                           THE02890
      IF(NT(J).GT.0)GOTO 36                                             THE02900
      CALL LAMDA(I,J,PCTVIS,DETRAT,PSUBK)                               THE02910
      DETRAT=DETRAT*RF                                                  THE02920
      QV=EXP(-(FL(I)*PROP*DETRAT*DELT*FL(J)))                           THE02930
      Q(I,J)=Q(I,J)*QV                                                  THE02940
      GOTO 19                                                           THE02950
   36 Q(I,J)=0.0                                                        THE02960
      GOTO 19                                                           THE02970
   34 IF(IAA.EQ.1) GOTO 19                                              THE02980
      Q(I,J)=1.0                                                        THE02990
      GOTO 19                                                           THE03000
   15 IF(NLOSC(I,J).LE.3) GOTO 19                                       THE03010
      Q(I,J)=1.0                                                        THE03020
   19 CONTINUE                                                          THE03030
   14 CONTINUE                                                          THE03040
      IF(IAA.EQ.K) GOTO 38                                              THE03050
      FR=TNKFR                                                          THE03060
      IAA=K                                                             THE03070
      IBB=L                                                             THE03080
      ICC=1                                                             THE03090
      ICD=NRJ                                                           THE03100
      OP=1.0                                                            THE03110
      GOTO 37                                                           THE03120
C                                                                       THE03130
C                                                                       THE03140
C                                                                       THE03150
C                                                                       THE03160
C                                                                       THE03170
C     FIRE ALLOCATION.                                                  THE03180
C                                                                       THE03190
C                                                                       THE03200
C                                                                       THE03210
C                                                                       THE03220
C                                                                       THE03230
   38 DO 28 I=1,L                                                       THE03240
   28 NA(I)=0                                                           THE03250
      DO 26 I=1,L                                                       THE03260
      IF(IUSTAT(I).EQ.2) GOTO 26                                        THE03270
      IF(NT(I).EQ.0) GOTO 26                                            THE03280
      DO 27 J=1,3                                                       THE03290
      APOA(I,J)=0.0                                                     THE03300
   27 CONTINUE                                                          THE03310
      IF(NT(I).EQ.1) GOTO 78                                            THE03320
      IF(NT(I).EQ.2) GOTO 29                                            THE03330
      NOT=3                                                             THE03340
      MM1=LOT(I,1)                                                      THE03350
      MM2=LOT(I,2)                                                      THE03360
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      MM3=LOT(I,3)                                                      THE03370
      PROB=(1.0-Q(I,MM1))*Q(I,MM2)*Q(I,MM3)                             THE03380
      APOA(I,1)=APOA(I,1)+PTT(1,1)*PROB                                 THE03390
      PROB=Q(I,MM1)*(1.0-Q(I,MM2))*Q(I,MM3)                             THE03400
      APOA(I,2)=APOA(I,2)+PTT(1,1)*PROB                                 THE03410
      PROB=Q(I,MM1)*Q(I,MM2)*(1.0-Q(I,MM3))                             THE03420
      APOA(I,3)=APOA(I,3)+PTT(1,1)*PROB                                 THE03430
      PROB=(1.0-Q(I,MM1))*(1.0-Q(I,MM2))*Q(I,MM3)                       THE03440
      APOA(I,1)=APOA(I,1)+PTT(1,2)*PROB                                 THE03450
      APOA(I,2)=APOA(I,2)+PTT(2,2)*PROB                                 THE03460
      PROB=(1.0-Q(I,MM1))*Q(I,MM2)*(1.0-Q(I,MM3))                       THE03470
      APOA(I,1)=APOA(I,1)+PTT(1,2)*PROB                                 THE03480
      APOA(I,3)=APOA(I,3)+PTT(2,2)*PROB                                 THE03490
      PROB=Q(I,MM1)*(1.0-Q(I,MM2))*(1.0-Q(I,MM3))                       THE03500
      APOA(I,2)=APOA(I,2)+PTT(1,2)*PROB                                 THE03510
      APOA(I,3)=APOA(I,3)+PTT(2,2)*PROB                                 THE03520
      PROB=(1.0-Q(I,MM1))*(1.0-Q(I,MM2))*(1.0-Q(I,MM3))                 THE03530
      APOA(I,1)=APOA(I,1)+PTT(1,3)*PROB                                 THE03540
      APOA(I,2)=APOA(I,2)+PTT(2,3)*PROB                                 THE03550
      APOA(I,3)=APOA(I,3)+PTT(3,3)*PROB                                 THE03560
   30 DO 44 J=1,NCT                                                     THE03570
      KK=LOT(I,J)                                                       THE03580
      NA(KK)=NA(KK)+1                                                   THE03590
      IN=NA(KK)                                                         THE03600
      LCA(KK,IN)=I                                                      THE03610
      PCA(KK,IN)=APOA(I,J)                                              THE03620
   44 CONTINUE                                                          THE03630
      GOTO 26                                                           THE03640
   29 NOT=2                                                             THE03650
      MM1=LOT(I,1)                                                      THE03660
      MM2=LOT(I,2)                                                      THE03670
      PROB=(1.0-Q(I,MM1))*Q(I,MM2)                                      THE03680
      APOA(I,1)=APOA(I,1)+PTT(1,1)*PROB                                 THE03690
      PROB=Q(I,MM1)*(1.0-Q(I,MM2))                                      THE03700
      APOA(I,2)=APOA(I,2)+PTT(1,1)*PROB                                 THE03710
      PROB=(1.0-Q(I,MM1))*(1.0-Q(I,MM2))                                THE03720
      APOA(I,1)=APOA(I,1)+PTT(1,2)*PROB                                 THE03730
      APOA(I,2)=APOA(I,2)+PTT(2,2)*PROB                                 THE03740
      GOTO 30                                                           THE03750
   78 NOT=1                                                             THE03760
      MM1=LOT(I,1)                                                      THE03770
      PROB=1.0-Q(I,MM1)                                                 THE03780
      APOA(I,1)=APOA(I,1)+PTT(1,1)*PROB                                 THE03790
      GOTO 30                                                           THE03800
   26 CONTINUE                                                          THE03810
C                                                                       THE03820
C                                                                       THE03830
C                                                                       THE03840
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C
C
C     ATTRITION.
C
C
C
C
C
      SUMR=0.0
      SUMB=0.0
      DO 40 I=1,L
      IF(IUSTAT(I).EQ.2) GOTO 40
      M6=NA(I)
      SUM=0.0
      IF(M6.EQ.0) GOTO 47
      DO 41 J=1,M6
      M7=LOA(I,J)
      IF(M7.LT.K) GOTO 42
      ITYPE=2
      GOTO 43
   42 ITYPE=1
   43 RANGE=SQRT((X(I)-X(M7))**2+(Y(I)-Y(M7))**2)
      CALL ETK(ITYPE,RANGE,T)
      AJI=1.0/T
      SUM=SUM+AJI*FL(M7)*POA(I,J)*DELT
   41 CONTINUE
   47 OFL(I)=FL(I)
      FL(I)=FL(I)-SUM
      IF(FL(I).GT.ZL) GOTO 46
      FL(I)=0.0
      IUSTAT(I)=2
   46 IF(I.LT.K) GOTO 60
      SUMB=SUMB+FL(I)
      GOTO 75
   60 SUMR=SUMR+FL(I)
   75 TPOL(I)=(FO(I)-FL(I))/FO(I)
      POL(I)=(OFL(I)-FL(I))/OFL(I)
      RTPOL=(SUMRO-SUMR)/SUMRO
      BTPOL=(SUMBO-SUMB)/SUMBO
   40 CONTINUE
C
C
C
C
C
C     PRINT AND CHECK FOR BATTLE DETERMINATION.
C
C
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C                                                                       THE04330
C                                                                       THE04340
C                                                                       THE04350
      ITIME=IC*10                                                       THE04360
      RAX=0.0                                                           THE04370
      RAY=0.0                                                           THE04380
      MONE=0                                                            THE04390
      DO 57 I=1,NRU                                                     THE04400
      IF(IUSTAT(I).EQ.2) GOTO 57                                        THE04410
      RAX=RAX+X(I)                                                      THE04420
      RAY=RAY+Y(I)                                                      THE04430
      MONE=MONE+1                                                       THE04440
   57 CONTINUE                                                          THE04450
      IF(MONE.EQ.0) GOTO 125                                            THE0446C
      RAX=RAX/MONE                                                      THE04470
      RAY=RAY/MONE                                                      THE04480
      BAX=0.0                                                           THE04490
      BAY=0.0                                                           THE04500
      MONE=0                                                            THE04510
      DO 58 I=K,L                                                       THE04520
      IF(IUSTAT(I).EQ.2) GOTO 58                                        THE04530
      BAX=BAX+X(I)                                                      THE04540
      BAY=BAY+Y(I)                                                      THE04550
      MONE=MONE+1                                                       THE04560
   58 CCNTINUE                                                          THE04570
      IF(MONE.EQ.0) GOTO 125                                            THE04580
      BAX=BAX/MONE                                                      THE04590
      BAY=BAY/MONE                                                      THE04600
      AVD=SQRT((RAX-BAX)**2+(RAY-BAY)**2)                               THE04610
  125 MP=MP+1                                                           THE04620
      IF(MP.LE.4) GOTO 99                                               THE04630
      WRITE(6,127)                                                      THE04640
  127 FCRMAT('1')                                                       THE04650
      MP=1                                                              THE04660
   99 WRITE(6,112)ITIME,AVD                                             THE04670
  112 FCRMAT(//1X,'TIME=',I4,1X,'SEC.'/1X,'AVERAGE RANGE BETWEEN RED ANDTHE04680
     1 BLUE=',F6.1,1X,'M'//)                                            THE04690
      WRITE(6,113)                                                      THE04700
  113 FCRMAT(1X,'UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS'THE04710
     1)                                                                 THE04720
      DO 59 I=1,L                                                       THE04730
      N6=NT(I)                                                          THE04740
      IF(N6.NE.0) GOTO 48                                               THE04750
      WRITE(6,264)I,II(I),FL(I),IUSTAT(I),TPOL(I)                       THE04760
  264 FORMAT(2X,I1,6X,I3,7X,F5.3,7X,I1,6X,F5.3)                         THE04770
      GOTO 59                                                           THE04780
   48 WRITE(6,114)I,II(I),FL(I),IUSTAT(I),TPOL(I),(LOT(I,J),J=1,N6)     THE04790
  114 FORMAT(2X,I1,6X,I3,7X,F5.3,7X,I1,6X,F5.3,5X,3(I1,1X)//)           THE04800
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   59 CONTINUE                                                          THE04810
      WRITE(6,115)RTPOL                                                 THE04820
  115 FORMAT(1X,'RED TOTAL PERCENTAGE OF LOST=',F5.3)                   THE04830
      WRITE(6,116)BTPOL                                                 THE04840
  116 FORMAT(1X,'BLUE TOTAL PERCENTAGE OF LOST=',F5.3///)               THE04850
C                                                                       THE04860
C                                                                       THE04870
C                                                                       THE04880
C                                                                       THE04890
C                                                                       THE04900
C     CHECK FOR BATTLE DETERMINATION.                                   THE04910
C                                                                       THE04920
C                                                                       THE04930
C                                                                       THE04940
C                                                                       THE04950
C                                                                       THE04960
      IOT=0                                                             THE04970
      DO 53 I=1,NRU                                                     THE04980
      IF(FL(I).EQ.0.0) GOTO 53                                          THE04990
      IOT=1                                                             THE05000
   53 CONTINUE                                                          THE05010
      IF(IOT.EQ.1) GOTO 54                                              THE05020
      WRITE(6,117)                                                      THE05030
  117 FORMAT(1X,'*** RED FORCE IS ELIMINATED.  END OF BATTLE.')         THE05040
      GOTO 66                                                           THE05050
   54 ICT=0                                                             THE05060
      DO 55 I=K,L                                                       THE05070
      IF(FL(I).EQ.0.0) GOTO 55                                          THE05080
      IOT=1                                                             THE05090
   55 CONTINUE                                                          THE05100
      IF(IOT.EQ.1) GOTO 56                                              THE05110
      WRITE(6,118)                                                      THE05120
  118 FORMAT(1X,'***  BLUE FORCE IS ELIMINATED. END OF BATTLE.')        THE05130
      GOTO 66                                                           THE05140
   56 IF(AVD.GT.500.0) GOTO 65                                          THE05150
      WRITE(6,119)                                                      THE05160
  119 FORMAT(1X,'*** DISTANCE BETWEEN FORCES IS TOO CLOSE. END OF BATTLETHE05170
     1')                                                                THE05180
      GOTO 66                                                           THE05190
   65 IC=IC+1                                                           THE05200
      GOTO 67                                                           THE05210
   66 STOP                                                              THE05220
      DEBUG SUBCHK                                                      THE05230
      END                                                               THE05240
C                                                                       THE05250
C                                                                       THE05260
C                                                                       THE05270
C                                                                       THE05280
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C     SUBROUTINES.                                                      THE05290
C                                                                       THE05300
C                                                                       THE05310
C                                                                       THE05320
C                                                                       THE05330
      SUBROUTINE LAMDA(I,J,PCTVIS,DETRAT,PK)                            THE05340
C     SUBROUTINE TO COMPUTE DETECTION RATE (DETRAT) OF TARGET J         THE05350
C     BY OBSERVER I GIVEN THE VISIBLE FRACTION (PCTVIS).                THE05360
      COMMON /GRP1/ IPRDIR(6),ISECWD(6),MVTDIR(6),X(6),Y(6),SPD(6)      THE05370
      TCFACT=1.0                                                        THE05380
      ZEROL=0.00001                                                     THE05390
      PAI=22.0/7.0                                                      THE05400
    7 D=(ISECWD(I)*PAI/180.0)/2.0                                       THE05410
      BBB=(1.0/(2.0*(SIN(D)-D*COS(D))))                                 THE05420
      IF(ABS(BBB).LT.ZEROL) BBB=0.0                                     THE05430
      AAA=(-BBB)*COS(D)                                                 THE05440
      IF(ABS(AAA).LT.ZEROL) AAA=0.0                                     THE05450
      OTANG=ATAN2((Y(J)-Y(I)),(X(J)-X(I)))                              THE05460
      PD=IPRDIR(I)*PAI/180.0                                            THE05470
      IF((PD*OTANG).GE.0.0) GOTO 1                                      THE05480
      IF(PD.LT.0.0) GOTO 9                                              THE05490
      ANGLE=2*PAI+OTANG-PD                                              THE05500
      GOTO 10                                                           THE05510
    9 ANGLE=2*PAI+PD-OTANG                                              THE05520
   10 IF(ANGLE.GT.PAI) ANGLE=2*PAI-ANGLE                                THE05530
      GOTO 2                                                            THE05540
    1 ANGLE=ABS(PD-OTANG)                                               THE05550
    2 IF(ANGLE.GT.D) GOTO 3                                             THE05560
      ANGLFT=ANGLE+(15.0*PAI/180.0)                                     THE05570
      IF(ANGLFT.GT.D) ANGLFT=D                                          THE05580
      ANGRT=ANGLE-(15.0*PAI/180.0)                                      THE05590
      PK=BBB*(SIN(ANGLFT)-SIN(ANGRT))+AAA*(ANGLFT-ANGRT)                THE05600
      IF(PK.LT.0.0) GOTO 3                                              THE05610
      IF(PK.GT.1.0) GOTO 5                                              THE05620
      GOTO 8                                                            THE05630
    3 PK=0.0                                                            THE05640
      DETRAT=0.0                                                        THE05650
      GOTO 6                                                            THE05660
    5 PK=1.0                                                            THE05670
    8 RANGE=SQRT((X(J)-X(I))**2+(Y(J)-Y(I))**2)                         THE05680
      RR=0.001*RANGE/PCTVIS                                             THE05690
      TOANG=ATAN2((Y(I)-Y(J)),(X(I)-X(J)))                              THE05700
      AD=MVTDIR(J)*PAI/180.0                                            THE05710
      HORVEL=ABS(SPD(J)*SIN(TOANG-AD))                                  THE05720
      DENOM=1.453+TCFACT*(0.5978+2.188*(RR**2)-0.5038*HORVEL)           THE05730
      IF(DENOM.LE.ZEROL) DENOM=ZEROL                                    THE05740
      DETRAT=0.003+1.088/DENOM                                          THE05750
      DETRAT=DETRAT*PK                                                  THE05760
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    6 RETURN                                                              THE05770
      DEBUG SUBCHK                                                        THE05780
      END                                                                 THE05790
C                                                                         THE05800
C                                                                         THE05810
C                                                                         THE05820
      SUBROUTINE ETK(I,RANGE,T)                                           THE05830
C     SUBROUTINE TO COMPUTE EXPECTED TIME TO KILL A TARGET.              THE05840
      COMMON /GRP2/ TA(2),T1(2),TH(2),TM(2),TF1(2),TF2(2),TF3(2),        THE05850
     1P(2,6),PHH(2,6),PHM(2,6),PKH(2,6),TF(2)                             THE05860
      IF(I.EQ.2) GOTO 5                                                   THE05870
      TF(I)=TF1(I)                                                        THE05880
      GOTO 6                                                              THE05890
    5 IF(RANGE.GT.1000.0) GOTO 7                                          THE05900
      TF(I)=TF1(I)-(TF1(I)*(1000.0-RANGE)/1000.0)                         THE05910
      GOTO 6                                                              THE05920
    7 IF(RANGE.GT.2000.0) GOTO 8                                          THE05930
      TF(I)=TF2(I)-((TF2(I)-TF1(I))*(2000.0-RANGE)/1000.0)                THE05940
      GOTO 6                                                              THE05950
    8 TF(I)=TF3(I)-((TF3(I)-TF2(I))*(3000.0-RANGE)/1000.0)                THE05960
    6 J=(RANGE+250.0)/500.0                                               THE05970
      IF(J.GT.6) J=6                                                      THE05980
      T=TA(I)+T1(I)-TH(I)+((TH(I)+TF(I))/PKH(I,J))+((TM(I)+TF(I))/        THE05990
     1PHM(I,J))*((1.0-PHH(I,J))/PKH(I,J)+PHH(I,J)-P(I,J))                 THE06000
      RETURN                                                              THE06010
      DEBUG SUBCHK                                                        THE06020
      END                                                                 THE06030
C                                                                         THE06040
C                                                                         THE06050
C                                                                         THE06060
      SUBROUTINE SORT(I,M)                                                THE06070
      COMMON /GRP5/ LOT(6,6),ROT(6,6)                                     THE06080
      DO 19 J=1,M                                                         THE06090
      IF(ROT(I,M).GE.ROT(I,J)) GOTO 19                                    THE06100
   21 R=ROT(I,J)                                                          THE06110
      NN=LOT(I,J)                                                         THE06120
      ROT(I,J)=ROT(I,M)                                                   THE06130
      LOT(I,J)=LOT(I,M)                                                   THE06140
      ROT(I,M)=R                                                          THE06150
      LOT(I,M)=NN                                                         THE06160
   19 CONTINUE                                                            THE06170
      RETURN                                                              THE06180
      DEBUG SUBCHK                                                        THE06190
      END                                                                 THE06200
      SUBROUTINE SETUP                                                    THE06210
      COMMON /HILLS/ XC(100),YC(100),PEAK(100),SX(100),SY(100),RHO(100)  THE06220
      COMMON /HILLS/ SCALE(100),TWORHO(100),TWOSCL(100),BASE              THE06230
      COMMON /HILLS/ NHILLS                                               THE06240
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      COMMON /COVER/ CXC(150),CYC(150),CPEAK(150),CPXX(150),CPYY(150)   THE06250
      COMMON /COVER/ CPXY(150),NCVELS                                   THE06260
      COMMON /COUNTR/KH,KHW,KV,KN,KGRS,KELL,KINT                        THE06270
      COMMON /GRID/ LST(10,10),NHL(10,10),LISTH(450),KHREP(100),KTREP   THE06280
      COMMON /GRID/ LSTC(10,10),NC(10,10),LISTC(400),KCREP(150)         THE06300
      READ(1,7) NHILLS                                                  THE06300
      READ(1,47) BASE                                                   THE06310
47    FORMAT(F10.4)                                                     THE06320
7     FORMAT(I6)                                                        THE06330
17    FORMAT(5F8.3,F6.4)                                                THE06340
      DO 50 I=1,NHILLS                                                  THE06350
      READ(1,17) XC(I),YC(I),PEAK(I),SX(I),SY(I),RHO(I)                 THE06360
50    CONTINUE                                                          THE06370
      READ(1,37)LST                                                     THE06380
      READ(1,37)NHL                                                     THE06390
      READ(1,7)NHTOT                                                    THE06400
      READ(1,37)(LISTH(I),I=1,NHTOT)                                    THE06410
37    FORMAT(16I5)                                                      THE06420
      READ(1,7)NCVELS                                                   THE06430
      IF(NCVELS.EQ.0) GO TO 65                                          THE06440
      DO 60 I=1,NCVELS                                                  THE06450
      READ(1,27)CXC(I),CYC(I),CPEAK(I),CPXX(I),CPYY(I),CPXY(I)          THE06460
27    FORMAT(3F10.4,3E13.7)                                             THE06470
      KCREP(I)=-2147483600                                              THE06480
60    CONTINUE                                                          THE06490
      READ(1,37)LSTC                                                    THE06500
      READ(1,37)NC                                                      THE06510
      READ(1,7)NCTOT                                                    THE06520
      READ(1,37)(LISTC(I),I=1,NCTOT)                                    THE06530
   65 DO 100 I=1,NHILLS                                                 THE06540
      SX(I)=SX(I)*1.625                                                 THE06550
      SY(I)=SY(I)*1.625                                                 THE06560
      XC(I)=(XC(I)-500.)*100.                                           THE06570
      YC(I)=(YC(I)-930.)*100.                                           THE06580
      TWORHO(I)=2.*RHO(I)                                               THE06590
      SCALE(I)=-1./(2.*(1.-RHO(I)**2))                                  THE06600
      TWOSCL(I)=2.*SCALE(I)                                             THE06610
      KHREP(I)=-2147483600                                              THE06620
C  ALL VALUES NOW IN METERS ON 0 -- 10,000 GRID                         THE06630
100   CONTINUE                                                          THE06640
      KTREP=-2147483600                                                 THE06650
      KH=0                                                              THE06660
      KHW=0                                                             THE06670
      KV=0                                                              THE06680
      KN=0                                                              THE06690
      KGRS=0                                                            THE06700
      KELL=0                                                            THE06710
      KINT=0                                                            THE06720
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      RETURN                                                            THE06730
      DEBUG SUBCHK                                                      THE06740
      END                                                               THE06750
      SUBROUTINE LOS(XA,YA,TMACA,TMICA,SIZEA,XB,YB,TMACB,TMICB,SIZEB,   THE06760
     -LATOB,LBTOA,VISFRA,VISFRB)                                        THE06770
      COMMON /HILLS/ XC(100),YC(100),PEAK(100),SX(100),SY(100),RHO(100) THE06780
      COMMON /HILLS/ SCALE(100),TWORHC(100),TWOSCL(100),BASE            THE06790
      COMMON /HILLS/ NHILLS                                             THE06800
      COMMON /COVER/ CXC(150),CYC(150),CPEAK(150),CPXX(150),CPYY(150)   THE06810
      COMMON /COVER/ CPXY(150),NCVELS                                   THE06820
      COMMON /COUNTR/KH, KHW, KV, KN, KGRS, KELL, KINT                  THE06830
      COMMON /GRID/ LST(10,10),NHL(10,10),LISTH(450),KHREP(100),KTREP   THE06840
      COMMON /GRID/ LSTC(10,10),NC(10,10),LISTC(400),KCREF(150)         THE06850
      DIMENSION IGX(20),IGY(20),IEL(100),CS1(100),CS2(100)              THE06860
      DATA NGRID/10/,GSIZE/1000./                                       THE06870
C SUBROUTINE TO COMPUTE FRACTION VISIBLE FOR OBSERVER TARGET PAIRS      THE06880
      VISFRA=1.                                                         THE06890
      VISFRB=1.                                                         THE06900
      XBA=XB-XA                                                         THE06910
      YBA=YB-YA                                                         THE06920
      IF((XBA.EQ.0.).AND.(YBA.EQ.0.)) RETURN                            THE06930
      IF(SIZEA+TMICA.LE.0.) GO TO 510                                   THE06940
      IF(SIZEB+TMICB.LE.0.) GO TO 510                                   THE06950
      IF(TMICA.LT.0.) VISFRA=1.0+TMICA/SIZEA                            THE06960
      IF(TMICB.LT.0.) VISFRB=1.0+TMICB/SIZEB                            THE06970
      ZA=TMACA + TMICA + SIZEA                                          THE06980
      ZB=TMACB + TMICB + SIZEB                                          THE06990
      KTREP=KTREP+1                                                     THE07000
      ZBA=ZB-ZA                                                         THE07010
      XBASQ=XBA*XBA                                                     THE07020
      YBASQ=YBA*YBA                                                     THE07030
      XYBA=XBA*YBA                                                      THE07040
      TWOXBA=2.*XBA                                                     THE07050
      TWOYBA=2.*YBA                                                     THE07060
C COMPUTE GRID SQUARES CROSSED BY A TO B LINE                           THE07070
      NGRSQ=0                                                           THE07080
      IF(XBA) 110,95,100                                                THE07090
95    XBA=0.1                                                           THE07100
100   ISGX=-1                                                           THE07110
      XINC=GSIZE/XBA                                                    THE07120
      GO TO 120                                                         THE07130
110   ISGX=1                                                            THE07140
      XINC=-GSIZE/XBA                                                   THE07150
120   IF(YBA) 140,125,130                                               THE07160
125   YBA=0.1                                                           THE07170
130   ISGY=-1                                                           THE07180
      YINC=GSIZE/YBA                                                    THE07190
      GO TO 150                                                         THE07200
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 140  ISGY=1                                                            THE07210
      YINC=-GSIZE/Y3A                                                   THE07220
 150  IX=1+IFIX(XB/GSIZE)                                               THE07230
      IF(IX.GT.NGRID) IX=NGRID                                          THE07240
      IY=1+IFIX(YB/GSIZE)                                               THE07250
      IF(IY.GT.NGRID) IY=NGRID                                          THE07260
      XNEXT=GSIZE*(FLOAT(IX)+0.5*(ISGX-1.))                             THE07270
      YNEXT=GSIZE*(FLOAT(IY)+0.5*(ISGY-1.))                             THE07280
      XSTEP=(XB-XNEXT)/XBA                                              THE07290
      YSTEP=(YB-YNEXT)/YBA                                              THE07300
 160  NGRSQ=NGRSQ+1                                                     THE07310
      IGX(NGRSQ)=IX                                                     THE07320
      IGY(NGRSQ)=IY                                                     THE07330
      IF((XSTEP.GT.1.).AND.(YSTEP.GT.1.)) GO TO 2C0                     THE07340
      IF(XSTEP-YSTEP) 170,180,190                                       THE07350
 170  IX=IX +ISGX                                                       THE07360
      XSTEP=XSTEP+XINC                                                  THE07370
      GO TO 160                                                         THE07380
 180  IX=IX+ISGX                                                        THE07390
      XSTEP=XSTEP+XINC                                                  THE07400
 190  IY=IY+ISGY                                                        THE07410
      YSTEP=YSTEP+YINC                                                  THE07420
      GO TO 160                                                         THE07430
 200  KGRS=KGRS+NGRSQ                                                   THE07440
C GRID SQUARE LIST NOW COMPLETE IN IGX, IGY WITH NGRSQ ENTRIES          THE07450
C                                                                       THE07460
C NOW FIND WHICH COVER ELLIPSES TOUCH THE A TO B LINE,                  THE07470
C CHECK ELEVATIONS AT S1 AND S2 FOR EACH SJCH ELLIPSE                   THE07480
      NELS=0                                                            THE07490
      CFTMAX=0.                                                         THE07500
      IF(NCVELS.EC.0) GCTO 270                                          THE07510
      DO 260 K=1,NGRSQ                                                  THE07520
      IX=IGX(K)                                                         THE07530
      IY=IGY(K)                                                         THE07540
      N=NC(IX,IY)                                                       THE07550
      IF(N.EQ.0) GO TO 260                                              THE07560
      LS=LSTC(IX,IY)                                                    THE07570
      LEND=LS+N-1                                                       THE07580
      DC 250 L=LS,LEND                                                  THE07590
      KELL=KELL+1                                                       THE07600
      IC=LISTC(L)                                                       THE07610
      IF(KCREP(IC).EQ.KTREP) GO TO 250                                  THE07620
      KCREP(IC)=KTREP                                                   THE07630
      RX=XA-CXC(IC)                                                     THE07640
      RY=YA-CYC(IC)                                                     THE07650
      PXX=CPXX(IC)                                                      THE07660
      PYY=CPYY(IC)                                                      THE07670
      PXY=CPXY(IC)                                                      THE07680
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      AA=PXX*XBASQ+PYY*YBASQ+PXY*XYBA                                   THE07690
      BB=PXX*TWOXBA*RX+PYY*TWOYBA*RY+PXY*(RX*YBA+RY*XBA)                THE07700
      CC=PXX*RX*RX+PYY*RY*RY+PXY*RX*RY-1.0                              THE07710
      ARG=BB*BB-4.0*AA*CC                                               THE07720
      IF(ARG.LE.0.) GO TO 250                                           THE07730
      SQ=SQRT(ARG)                                                      THE07740
      S1=-(BB+SQ)/(2.0*AA)                                              THE07750
      S2=(SQ-BB)/(2.0*AA)                                               THE07760
      IF(S1.GE.1.) GO TO 250                                            THE07770
      IF(S2.LE.0.) GO TO 250                                            THE07780
      IF(S1.LE.0.)  GO TO 510                                           THE07790
      IF(S2.GE.1.) GO TO 510                                            THE07800
C NOW CHECK LOS AT S1 AND S2                                             THE07810
      KINT=KINT+1                                                       THE07820
      CPK=CPEAK(IC)                                                     THE07830
      XS=XA+S2*XBA                                                      THE07840
      YS=YA+S2*YBA                                                      THE07850
      CALL ELEV(XS,YS,HTS)                                              THE07860
      HTS=HTS+CPK                                                       THE07870
      ZS=ZA+S2*ZBA                                                      THE07880
      IF(LATOB.EQ.0) GO TO 210                                          THE07890
      CALL KOVER(ZA,TMACB,SIZEB,ZB,S2,HTS,ZS,VISFRB)                    THE07900
      IF(VISFRB.LE.0.) GO TO 510                                        THE07910
  210 IF(LBTOA.EQ.0) GO TO 220                                          THE07920
      S=1.-S2                                                           THE07930
      CALL KOVER(ZB,TMACA,SIZEA,ZA,S,HTS,ZS,VISFRA)                     THE07940
      IF(VISFRA.LE.0.) GO TO 510                                        THE07950
  220 XS=XA+S1*XBA                                                      THE07960
      YS=YA+S1*YBA                                                      THE07970
      CALL ELEV(XS,YS,HTS)                                              THE07980
      HTS=HTS+CPK                                                       THE07990
      ZS=ZA+S1*ZBA                                                      THE08000
      IF(LATOB.EQ.0) GO TO 230                                          THE08010
      CALL KOVER(ZA,TMACB,SIZEB,ZB,S1,HTS,ZS,VISFRB)                    THE08020
      IF(VISFRB.LE.0.) GO TO 510                                        THE08030
  230 IF(LBTOA.EQ.0) GO TO 240                                          THE08040
      S=1.0-S1                                                          THE08050
      CALL KOVER(ZB,TMACA,SIZEA,ZA,S,HTS,ZS,VISFRA)                     THE08060
      IF(VISFRA.LE.0.) GO TO 510                                        THE08070
  240 NELS=NELS+1                                                       THE08080
      IEL(NELS)=IC                                                      THE08090
      CS1(NELS)=S1                                                      THE08100
      CS2(NELS)=S2                                                      THE08110
      IF(CPK.GT.CHTMAX) CHTMAX=CPK                                      THE08120
  250 CONTINUE                                                          THE08130
  260 CONTINUE                                                          THE08140
C ALL ELLIPSES CHECKED                                                  THE08150
C                                                                       THE08160
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C NOW START ON THE HILLS                                                THE08170
  270 DO 600 K=1,NGRSQ                                                  THE08180
      IX=IGX(K)                                                         THE08190
      IY=IGY(K)                                                         THE08200
      IF(NHL(IX,IY).EQ.0) GO TO 600                                     THE08210
      LS=LST(IX,IY)                                                     THE08220
      LEND=LS+NHL(IX,IY) -1                                             THE08230
      DO 500 L=LS,LEND                                                  THE08240
      I=LISTH(L)                                                        THE08250
      IF(KHREP(I).EQ.KTREP) GO TO 500                                   THE08260
      KHREP(I)=KTREP                                                    THE08270
C   PROCESSING FOR HILL I STARTS HERE                                   THE08280
      KH=KH+1                                                           THE08290
C COMPUTE W =TOP OF THIS HILL ALONG O-T LINE                            THE08300
      CX=XBA/SX(I)                                                      THE08310
      CY=YBA/SY(I)                                                      THE08320
      DX=(XA-XC(I))/SX(I)                                               THE08330
      DY=(YA-YC(I))/SY(I)                                               THE08340
      FQ=TWOSCL(I)*(CX*DX+CY*DY+RHO(I)*(CX*DY+CY*DX))                   THE08350
      GQ=SCALE(I)*(CX*CX+CY*CY+TWORHO(I)*CX*CY)                         THE08360
      IF(GQ .EQ.0.)  GO TO 500                                          THE08370
      W=-FQ/(2.*GQ)                                                     THE08380
      IF(ABS(W).GT.5.) GO TO 500                                        THE08390
      FSQ=FQ*FQ                                                         THE08400
      EQ=SCALE(I)*(DX*DX+DY*DY+TWORHO(I)*DX*DY)                         THE08410
      POWER=EQ-FSQ/(4.*GQ)                                              THE08420
      IF(POWER .LT. -3.) GO TO 500                                      THE08430
      HHW=PEAK(I)*EXP(POWER)                                            THE08440
      KHW=KHW+1                                                         THE08450
      IF(HHW.LE.BASE) GO TO 500                                         THE08460
      ZW=ZA+W*ZBA                                                       THE08470
      IF((W.LT.0.).OR.(W.GT.1.)) GO TO 300                              THE08480
      IF(HHW .GE. ZW) GO TO 510                                         THE08490
      CVHTW=0.                                                          THE08500
      IF(NELS.EQ.0) GO TO 300                                           THE08510
      DO 280 M=1,NELS                                                   THE08520
      IF((CS1(M).GE.W).OR.(CS2(M).LE.W)) GO TO 280                      THE08530
      IC=IEL(M)                                                         THE08540
      IF(CVHTW.LT.CPEAK(IC))  CVHTW=CPEAK(IC)                           THE08550
  280 CONTINUE                                                          THE08560
      IF((HHW+CVHTW).GE.ZW)  GO TO 510                                  THE08570
  300 IF(HHW+CHTMAX.LT.AMIN1(ZA-SIZEA,ZB-SIZEB)) GO TO 500              THE08580
C IF WE GET TO HERE THEN NEED TO FIND LOWEST SIGHT LINE OVER HILL       THE08590
C NEWTON ITERATION A TO B GIVING VISFRB                                 THE08600
      IF(LATOB.EQ.0) GO TO 400                                          THE08610
      KV=KV+1                                                           THE08620
      V=W                                                               THE08630
      HHV=HHW                                                           THE08640
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      NCT=0                                                             THE08650
      FV=FQ*V                                                           THE08660
      TWOGV=2.*GQ*V                                                     THE08670
330    FCNV=ZA+HHV*(TWOGV*V+FV-1.)                                      THE08680
      KN=KN+1                                                           THE08690
      FACTOR=(TWOGV*TWOGV+2.*(GQ+TWOGV*FQ)+FSQ)                         THE08700
      DFCNV=HHV*V*FACTOR                                                THE08710
      IF(ABS(DFCNV) .LT.1.E-10) GO TO 350                               THE08720
      V=V-FCNV/DFCNV                                                    THE08730
      IF(ABS(V).GT.5.)GO TO 400                                         THE08740
      FV=FQ*V                                                           THE08750
      TWOGV=2.*GQ*V                                                     THE08760
      POWER = EQ+FV+GQ*V*V                                              THE08770
      IF(POWER .LT. -3.) GO TO 400                                      THE08780
      HHV=PEAK(I)*EXP(POWER)                                            THE08790
      DHHV=HHV*(FQ+TWOGV)                                               THE08800
      ELV=ZA+DHHV*V                                                     THE08810
      IF (ABS(HHV-ELV) .LT.1.) GO TO 350                                THE08820
      NCT=NCT+1                                                         THE08830
      IF (NCT.LT.10) GO TO 330                                          THE08840
350   IF((V.LT.0.).OR.(V.GT.1.)) GO TO 400                              THE08850
      CVHTV=0.                                                          THE08860
      IF(NELS.EQ.0) GO TO 390                                           THE08870
      DO 380 M=1,NELS                                                   THE08880
      IF((CS1(M).GE.V).OR.(CS2(M).LE.V))GO TO 380                       THE08890
      IC=IEL(M)                                                         THE08900
      IF(CVHTV.LT.CPEAK(IC)) CVHTV=CPEAK(IC)                            THE08910
380   CONTINUE                                                          THE08920
390   HTV=HHV+CVHTV                                                     THE08930
      ZV=ZA+V*ZBA                                                       THE08940
      CALL KOVER(ZA,TMACB,SIZEB,ZB,V,HTV,ZV,VISFRB)                     THE08950
      IF (VISFRB.LE.0.) GO TO 510                                       THE08960
C NEWTON ITERATION B TO A GIVING VISFRA                                 THE08970
400   IF(LBTOA.EQ.0) GO TO 500                                          THE08980
      KV=KV+1                                                           THE08990
      V=W                                                               THE09000
      VM1=V-1.                                                          THE09010
      HHV=HHW                                                           THE09020
      NCT=0                                                             THE09030
      FV=FQ*V                                                           THE09040
      TWOGV=2.*GQ*V                                                     THE09050
430   FCNV=ZB+HHV*((FQ+TWOGV)*VM1-1.)                                   THE09060
      KN=KN+1                                                           THE09070
      FACTOR=(TWOGV*TWOGV+2.*(GQ+TWOGV*FQ)+FSQ)                         THE09080
      DFCNV=HHV*VM1*FACTOR                                              THE09090
      IF(ABS(DFCNV) .LT.1.E-10) GO TO 450                               THE09100
      V=V-FCNV/DFCNV                                                    THE09110
      IF(ABS(V).GT.5.)GO TO 500                                         THE09120
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      VM1=V-1.                                                          THE09130
      FV=FQ*V                                                           THE09140
      TWOGV=2.*GQ*V                                                     THE09150
      POWER = EQ+FV+GQ*V*V                                              THE09160
      IF(POWER .LT. -3.) GO TO 500                                      THE09170
      HHV=PEAK(I)*EXP(POWER)                                            THE09180
      DHHV=HHV*(FC+TWOGV)                                               THE09190
      ELV=ZB+DHHV*VM1                                                   THE09200
      IF (ABS(HHV-ELV) .LT.1.) GO TO 450                                THE09210
      NCT=NCT+1                                                         THE09220
      IF (NCT.LT.10) GO TO 430                                          THE09230
  450 IF((V.LT.0.).OR.(V.GT.1.)) GO TO 500                              THE09240
      CVHTV=0.                                                          THE09250
      IF(NELS.EQ.0) GO TO 490                                           THE09260
      DO 480 M=1,NELS                                                   THE09270
      IF((CS1(M).GE.V).OR.(CS2(M).LE.V))GO TO 480                       THE09280
      IC=IEL(M)                                                         THE09290
      IF(CVHTV.LT.CPEAK(IC)) CVHTV=CPEAK(IC)                            THE09300
  480 CONTINUE                                                          THE09310
  490 HTV=HHV+CVHTV                                                     THE09320
      ZV=ZA+V*ZBA                                                       THE09330
      S=-VM1                                                            THE09340
      CALL KOVER(ZB,TMACA,SIZEA,ZA,S,HTV,ZV,VISFRA)                     THE09350
      IF (VISFRA.LE.0.) GO TO 510                                       THE09360
  500 CONTINUE                                                          THE09370
  600 CONTINUE                                                          THE09380
      RETURN                                                            THE09390
  510 VISFRA=0.                                                         THE09400
      VISFRB=0.                                                         THE09410
      RETURN                                                            THE09420
      DEBUG SUBCHK                                                      THE09430
      END                                                               THE09440
      SUBROUTINE KOVER(ZO,TMACT,SIZET,ZT,S,HTS,ZS,VISFRT)               THE09450
      IF(S.EQ.0.) GO TO 2000                                            THE09460
      IF(HTS.GE.ZS) GO TO 2050                                          THE09470
      HEXT=ZO+(HTS-ZO)/S                                                THE09480
      EVIST=AMAX1(HEXT,TMACT)                                           THE09490
      IF(EVIST.GE.ZT) GO TO 2050                                        THE09500
      IF(EVIST.LE.ZT-SIZET) RETURN                                      THE09510
      VIS=(ZT-EVIST)/SIZET                                              THE09520
      IF(VIS.LT.VISFRT) VISFRT=VIS                                      THE09530
      RETURN                                                            THE09540
 2000 IF(HTS.LT.ZO) RETURN                                              THE09550
 2050 VISFRT=0.0                                                        THE09560
      RETURN                                                            THE09570
      END                                                               THE09580
      SUBROUTINE ELEV(X,Y,TMAC)                                         THE09590
      COMMON /HILLS/ XC(100),YC(100),PEAK(100),SX(100),SY(100),RHO(100) THE09600
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      COMMON /HILLS/ SCALE(100),TWORHO(100),TWOSCL(100),BASE            THE09610
      COMMON /HILLS/ NHILLS                                             THE09620
      COMMON /GRID/ LST(10,10),NHL(10,10),LISTH(450),KHREP(100),KTREP   THE09630
      COMMON /GRID/ LSTC(10,10),NC(10,10),LISTC(400),KCREP(150)         THE09640
      DATA NGRID/10/,GSIZE/1000./                                       THE09650
C FUNCTION TO COMPUTE TERRAIN ELEVATION FOR GIVEN X, Y COORDINATES.     THE09660
      ZMAX=BASE                                                         THE09670
      IX=1+IFIX(X/GSIZE)                                                THE09680
      IF(IX.GT.NGRID)   IX=NGRID                                        THE09690
      IY=1+IFIX(Y/GSIZE)                                                THE09700
      IF(IY.GT.NGRID)   IY=NGRID                                        THE09710
      IF(NHL(IX,IY).EQ.0) GO TO 150                                     THE09720
      LS=LST(IX,IY)                                                     THE09730
      LEND=LS+NHL(IX,IY)-1                                              THE09740
      DO 100 L=LS,LEND                                                  THE09750
      I=LISTH(L)                                                        THE09760
      QX=(X-XC(I))/SX(I)                                                THE09770
      QXSQ=QX*QX                                                        THE09780
      IF (QXSQ .GE.9.) GO TO 100                                        THE09790
      QY=(Y-YC(I))/SY(I)                                                THE09800
      QYSQ=QY*QY                                                        THE09810
      IF (QYSQ .GE. 9.) GO TO 100                                       THE09820
      QXY=TWORHO(I)*QX*QY                                               THE09830
      FACTOR=SCALE(I)*(QXSQ+QYSQ+QXY)                                   THE09840
      IF(FACTOR.LT.-3.) GO TO 100                                       THE09850
      HT=PEAK(I)*EXP(FACTOR)                                            THE09860
      IF(HT.LE.ZMAX) GO TO 100                                          THE09870
      ZMAX = HT                                                         THE09880
100   CONTINUE                                                          THE09890
150   TMAC=ZMAX                                                         THE09900
      RETURN                                                            THE09910
      DEBUG SUBCHK                                                      THE09920
      END                                                               THE09930
```

APPENDIX B

Definition of Variables in Computer Program

IPRDIR(I) = Primary direction of unit i

ISECWD(I) = Width of search section of unit i

MVTDIR(I) = Movement direction of unit i

X(I),Y(I) = Coordinates of unit i

SPD(I) = Speed of unit i

TA(K) = Time to acquire a target for the K^{th} weapon system type (K = 1, 2)

TI(K) = Time to fire first round after target acquired for the K^{th} weapon system type (K = 1, 2)

TH(K) = Time to fire a round following a hit for the K^{th} weapon system type (K = 1, 2)

TM(K) = Time to fire a round following a miss for the K^{th} weapon system type (K = 1, 2)

TF1(K) = Projectile time of flight to 1000 m for the K^{th} weapon system type (K = 1, 2)

TF2(K) = Projectile time of flight to 2000 m for the K^{th} weapon system type (K = 1, 2)

TF3(K) = Projectile time of flight to 3000 m for the K^{th} weapon system type (K = 1, 2)

P(I,J) = Probability of hit on first round. I = unit index. J = range index (J = 1, 2, 3, 4, 5, 6 corresponds to range = 500, 1000, 1500, 2000, 2500, 3000 meters)

PHH(I,J) = Probability of a hit on a round following a hit. For I and J see P(I,J)

PHM(I,J) = Probability of a hit on a round following a miss. For I and J see P(I,J)

PKH(I,J) = Probability of destroying a target given it is hit

NBU = Number of Blue units

NRU = Number of Red units

FL(I) = Force level of unit i

FO(I) = Initial force level of unit i

NOI(I) = Number of intervals in the i^{th} route I = 1,2,3)

XIC(I,J), YIC(I,J) = Coordinates of the center of the j^{th} interval in the i^{th} route

IDIR(I,J) = Direction of the j^{th} interval in the i^{th} route

AVSP = Average speed of moving non-firing units

IUSTAT(I) = Status of unit i

$$= \left\{ \begin{array}{ll} 0 & \text{does not fire} \\ 1 & \text{fires} \\ 2 & \text{destroyed} \end{array} \right\}$$

II(I) = Interval index for unit i

LOST(I,J) = 0 no line-of-sight between unit i and unit j
1 line-of-sight exists between unit i and unit j

VISFRA = Fraction of unit A (height fraction) as seen by unit B

VISFRB = Fraction of unit B (height fraction) as seen by unit A

SIZETK = Height of a tank

SIZETW = Height of a TOW vehicle

NT(I) = Number of targets of unit i

NF(I) = Number of time intervals unit i is firing continuously at the same route interval

DISMAX = The maximum horizontal distance allowed between the two Red units before delaying the faster one

NLOSC(I,J) = Number of continuous time intervals that line-of-sight does not exist between unit i and unit j

VISFR(I,J) = The height fraction of unit i as seen by unit j

RMINTK = Minimum firing range for a tank

RMINTW = Minimum firing range for a TOW

RMXTK = Maximum firing range for a tank

RMXTW = Maximum firing range for a TOW

TOWFR = Tow fire rate

TNKFR = Tank fire rate

NOD = Number of time intervals that a firing Red unit is delayed at the same route interval before moving to next route interval

RF = Detection rate reduction factor for a firing unit (in comparison with non-firing unit)

PM = The proportion of time a moving unit is busy with targets search

PTT(I,J) = Proportion of the surviving firepower allocated to the i^{th} target if there are j targets available

LOT(I,J) = The number of the j^{th} target of unit i

ROT(I,J) = The range of the j^{th} target of unit i

POA(I,J) = The proportion of the j^{th} attacker of unit i allocated to fire on unit i

APOA(I,J) = The average proportion of the j^{th} attacker of unit i allocated to fire on unit i

LOA(I,J) = The number of the j^{th} attacker of unit i

NA(I) = Number of attackers of unit i

OFL(I) = Force level of unit i at the previous time interval

POL(I) = Percentage of lost of unit i during the current time interval

TPOL(I) = Total percentage of lost (since the battle began) of unit i

RTPOL = Red total percentage of lost

BTPOL = Blue total percentage of lost

APPENDIX C

SENSITIVITY ANALYSIS RESULTS CONCERNING FIRE ALLOCATION

FIRE ALLOCATION POLICY 1

```
TIME=  10 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3260.1 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        2        3.000       0     0.0
 2        2        3.000       0     0.0
 3        2        3.000       0     0.0
 4      ***        3.000       0     0.0
 5      ***        3.000       0     0.0
 6      ***        3.000       0     0.0
RED TOTAL PERCENTAGE OF LOST=0.0
BLUE TOTAL PERCENTAGE OF LOST=0.0



TIME=  20 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        3        3.000       1     0.0       6
 2        3        3.000       1     0.0       6
 3        3        2.382       1     0.206     6
 4      ***        3.000       0     0.0
 5      ***        3.000       0     0.0
 6      ***        1.889       1     0.370     3 2 1

RED TOTAL PERCENTAGE OF LOST=0.069
BLUE TOTAL PERCENTAGE OF LOST=0.123



TIME=  30 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        3        3.000       1     0.0       6
 2        3        3.000       1     0.0       6
 3        3        1.992       1     0.336     6
 4      ***        3.000       0     0.0
 5      ***        3.000       0     0.0
 6      ***        0.836       1     0.721     3 2
RED TOTAL PERCENTAGE OF LOST=0.112
BLUE TOTAL PERCENTAGE OF LOST=0.240



TIME=  40 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3659.7 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        3        3.000       1     0.0       6
 2        3        3.000       1     0.0       6
 3        3        1.820       1     0.393     6
 4      ***        3.000       0     0.0
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000     3 2
RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333
```

```
TIME=  50 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3620.1 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         4        3.000         0      0.0
 2         4        3.000         0      0.0
 3         4        1.820         0      0.393
 4       ***        3.000         0      0.0
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333


TIME=  60 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3580.6 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         5        3.000         0      0.0
 2         5        3.000         0      0.0
 3         5        1.820         0      0.393
 4       ***        3.000         0      0.0
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333


TIME=  70 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3541.0 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         6        3.000         0      0.0
 2         6        3.000         0      0.0
 3         6        1.820         0      0.393
 4       ***        3.000         0      0.0
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333


TIME=  80 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3501.5 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         7        3.000         0      0.0
 2         7        3.000         0      0.0
 3         7        1.820         0      0.393
 4       ***        3.000         0      0.0
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333
```

```
TIME=  90 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3462.0 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1         8       2.406       1     0.198     4
 2         8       3.000       0     0.0
 3         8       1.820       0     0.393
 4       ***       2.751       1     0.083     1
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.197
BLUE TOTAL PERCENTAGE OF LOST=0.361



TIME= 100 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3435.6 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1         8       1.861       1     0.380     4
 2         9       3.000       0     0.0
 3         9       1.820       0     0.393
 4       ***       2.558       1     0.147     1
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.258
BLUE TOTAL PERCENTAGE OF LOST=0.382



TIME= 110 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3409.3 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1         8       1.354       1     0.549     4
 2        10       3.000       0     0.0
 3        10       1.820       0     0.393
 4       ***       2.417       1     0.194     1
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.314
BLUE TOTAL PERCENTAGE OF LOST=0.398



TIME= 120 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3369.8 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1         9       0.874       1     0.709     4
 2        11       3.000       0     0.0
 3        11       1.820       0     0.393
 4       ***       2.327       1     0.224     1
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.367
BLUE TOTAL PERCENTAGE OF LOST=0.408
```

```
TIME= 130 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3343.5 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         9        0.412         1      0.863      4
 2        12        3.000         1      0.0        4
 3        12        1.820         0      0.393
 4       ***        1.973         1      0.342      1 2
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.419
BLUE TOTAL PERCENTAGE OF LOST=0.447
```

```
TIME= 140 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3343.5 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         9        0.020         1      0.993      4
 2        12        3.000         1      0.0        4
 3        12        1.820         0      0.393
 4       ***        1.660         1      0.447      1 2
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.462
BLUE TOTAL PERCENTAGE OF LOST=0.482
```

```
TIME= 150 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3334.3 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000      4
 2        12        3.000         1      0.0        4
 3        13        1.820         0      0.393
 4       ***        1.349         1      0.550      1 2
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.464
BLUE TOTAL PERCENTAGE OF LOST=0.517
```

```
TIME= 160 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3295.5 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        13        2.732         1      0.089      4
 3        14        1.820         0      0.393
 4       ***        1.066         1      0.645      2
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.494
BLUE TOTAL PERCENTAGE OF LOST=0.548
```

```
TIME= 170 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3276.1 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0          2       1.000
 2        13        2.521        1       0.160       4
 3        15        1.820        0       0.393
 4        ***       0.804        1       0.732       2
 5        ***       3.000        0       0.0
 6        ***       0.0          2       1.000
RED TOTAL PERCENTAGE OF LOST=0.518
BLUE TOTAL PERCENTAGE OF LOST=0.577



TIME= 180 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3256.6 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0          2       1.000
 2        13        2.361        1       0.213       4
 3        16        1.820        0       0.393
 4        ***       0.560        1       0.813       2
 5        ***       3.000        0       0.0
 6        ***       0.0          2       1.000
RED TOTAL PERCENTAGE OF LOST=0.535
BLUE TOTAL PERCENTAGE OF LOST=0.604



TIME= 190 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0          2       1.000
 2        14        2.249        1       0.250       4
 3        17        1.820        0       0.393
 4        ***       0.326        1       0.891       2
 5        ***       3.000        0       0.0
 6        ***       0.0          2       1.000
RED TOTAL PERCENTAGE OF LOST=0.548
BLUE TOTAL PERCENTAGE OF LOST=0.630



TIME= 200 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0          2       1.000
 2        14        2.184        1       0.272       4
 3        17        1.820        0       0.393
 4        ***       0.100        1       0.967       2
 5        ***       3.000        0       0.0
 6        ***       0.0          2       1.000
RED TOTAL PERCENTAGE OF LOST=0.555
BLUE TOTAL PERCENTAGE OF LOST=0.656
```

```
TIME= 210 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3623.1 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2       1.000
 2        14        2.164         1       0.279        4
 3        17        1.820         0       0.393
 4       ***        0.0           2       1.000        2
 5       ***        3.000         0       0.0
 6       ***        0.0           2       1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 220 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3583.1 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2       1.000
 2        15        2.164         0       0.279
 3        18        1.820         0       0.393
 4       ***        0.0           2       1.000
 5       ***        3.000         0       0.0
 6       ***        0.0           2       1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 230 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3543.2 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2       1.000
 2        16        2.164         0       0.279
 3        19        1.820         0       0.393
 4       ***        0.0           2       1.000
 5       ***        3.000         0       0.0
 6       ***        0.0           2       1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 240 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3503.2 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2       1.000
 2        17        2.164         0       0.279
 3        20        1.820         0       0.393
 4       ***        0.0           2       1.000
 5       ***        3.000         0       0.0
 6       ***        0.0           2       1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 250 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3463.3 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        10      0.0          2     1.000
 2        18      2.164        0     0.279
 3        21      1.820        0     0.393
 4       ***      0.0          2     1.000
 5       ***      3.000        0     0.0
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667


TIME= 260 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3423.3 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        10      0.0          2     1.000
 2        19      2.164        0     0.279
 3        22      1.820        0     0.393
 4       ***      0.0          2     1.000
 5       ***      3.000        0     0.0
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667


TIME= 270 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3383.3 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        10      0.0          2     1.000
 2        20      2.164        0     0.279
 3        23      1.820        0     0.393
 4       ***      0.0          2     1.000
 5       ***      3.000        0     0.0
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667


TIME= 280 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3343.4 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        10      0.0          2     1.000
 2        21      2.164        0     0.279
 3        24      1.820        0     0.393
 4       ***      0.0          2     1.000
 5       ***      3.000        0     0.0
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 290 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3303.4 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        22        2.164         0      0.279
 3        25        1.820         0      0.393
 4       ***        0.0           2      1.000
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 300 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3263.4 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        23        2.164         0      0.279
 3        26        1.820         0      0.393
 4       ***        0.0           2      1.000
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 310 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3223.5 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        24        2.164         0      0.279
 3        27        1.820         0      0.393
 4       ***        0.0           2      1.000
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 320 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3183.5 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        25        2.164         0      0.279
 3        28        1.820         0      0.393
 4       ***        0.0           2      1.000
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667
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TIME= 330 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3143.6 M

UNIT  LOCATION   FORCE LEVEL   STATUS  LOST-PCT  TARGETS
 1       10        0.0           2     1.000
 2       26        2.164         0     0.279
 3       29        1.820         0     0.393
 4      ***        0.0           2     1.000
 5      ***        3.000         0     0.0
 6      ***        0.0           2     1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667



TIME= 340 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3103.6 M

UNIT  LOCATION   FORCE LEVEL   STATUS  LOST-PCT  TARGETS
 1       10        0.0           2     1.000
 2       27        2.164         0     0.279
 3       30        1.820         0     0.393
 4      ***        0.0           2     1.000
 5      ***        3.000         0     0.0
 6      ***        0.0           2     1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667



TIME= 350 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3063.7 M

UNIT  LOCATION   FORCE LEVEL   STATUS  LOST-PCT  TARGETS
 1       10        0.0           2     1.000
 2       28        2.164         0     0.279
 3       31        1.820         0     0.393
 4      ***        0.0           2     1.000
 5      ***        3.000         0     0.0
 6      ***        0.0           2     1.000
RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667



TIME= 360 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3023.7 M

UNIT  LOCATION   FORCE LEVEL   STATUS  LOST-PCT  TARGETS
 1       10        0.0           2     1.000
 2       29        2.164         0     0.279
 3       32        1.225         1     0.592     5
 4      ***        0.0           2     1.000
 5      ***        2.873         1     0.042     3
 6      ***        0.0           2     1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.681
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TIME= 370 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3003.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10       0.0           2      1.000
 2         30       2.164         0      0.279
 3         32       0.656         1      0.781       5
 4        ***       0.0           2      1.000
 5        ***       2.805         1      0.065       3
 6        ***       0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.687
BLUE TOTAL PERCENTAGE OF LOST=0.688
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TIME= 380 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2983.8 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10       0.0           2      1.000
 2         31       2.164         0      0.279
 3         32       0.100         1      0.967       5
 4        ***       0.0           2      1.000
 5        ***       2.795         1      0.068       3
 6        ***       0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.748
BLUE TOTAL PERCENTAGE OF LOST=0.689
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TIME= 390 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10       0.0           2      1.000
 2         32       2.164         1      0.279       5
 3         33       0.0           2      1.000       5
 4        ***       0.0           2      1.000
 5        ***       2.570         1      0.143       3 2
 6        ***       0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.760
BLUE TOTAL PERCENTAGE OF LOST=0.714
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TIME= 400 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10       0.0           2      1.000
 2         32       1.654         1      0.449       5
 3         33       0.0           2      1.000
 4        ***       0.0           2      1.000
 5        ***       2.399         1      0.200       2
 6        ***       0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.816
BLUE TOTAL PERCENTAGE OF LOST=0.733
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TIME= 410 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        32        1.178         1      0.607        5
 3        33        0.0           2      1.000
 4       ***        0.0           2      1.000
 5       ***        2.277         1      0.241        2
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.869
BLUE TOTAL PERCENTAGE OF LOST=0.747


TIME= 420 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2921.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        33        0.724         1      0.759        5
 3        33        0.0           2      1.000
 4       ***        0.0           2      1.000
 5       ***        2.202         1      0.266        2
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.920
BLUE TOTAL PERCENTAGE OF LOST=0.755


TIME= 430 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2921.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        33        0.286         1      0.905        5
 3        33        0.0           2      1.000
 4       ***        0.0           2      1.000
 5       ***        2.172         1      0.276        2
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.968
BLUE TOTAL PERCENTAGE OF LOST=0.759


TIME= 440 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2921.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        33        0.0           2      1.000        5
 3        33        0.0           2      1.000
 4       ***        0.0           2      1.000
 5       ***        2.172         1      0.276        2
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=1.000
BLUE TOTAL PERCENTAGE OF LOST=0.759


*** RED FORCE IS ELIMINATED.  END OF BATTLE.
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FIRE ALLOCATION POLICY 2

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TIME=  10 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3260.1 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          2        3.000        0       0.0
 2          2        3.000        0       0.0
 3          2        3.000        0       0.0
 4        ***        3.000        0       0.0
 5        ***        3.000        0       0.0
 6        ***        3.000        0       0.0
RED TOTAL PERCENTAGE OF LOST=0.0
BLUE TOTAL PERCENTAGE OF LOST=0.0


TIME=  20 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          3        2.970        1       0.010      6
 2          3        2.908        1       0.031      6
 3          3        2.505        1       0.165      6
 4        ***        3.000        0       0.0
 5        ***        3.000        0       0.0
 6        ***        1.887        1       0.371      3  2  1

RED TOTAL PERCENTAGE OF LOST=0.068
BLUE TOTAL PERCENTAGE OF LOST=0.124


TIME=  30 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          3        2.951        1       0.016      6
 2          3        2.851        1       0.050      6
 3          3        2.194        1       0.269      6
 4        ***        3.000        0       0.0
 5        ***        3.000        0       0.0
 6        ***        0.832        1       0.723      3  2  1

RED TOTAL PERCENTAGE OF LOST=0.112
BLUE TOTAL PERCENTAGE OF LOST=0.241


TIME=  40 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3659.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          3        2.943        1       0.019      6
 2          3        2.825        1       0.058      6
 3          3        2.057        1       0.314      6
 4        ***        3.000        0       0.0
 5        ***        3.000        0       0.0
 6        ***        0.0          2       1.000      3  2  1

RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333
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TIME=  50 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3620.1 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        4        2.943       0     0.019
 2        4        2.825       0     0.058
 3        4        2.057       0     0.314
 4       ***       3.000       0     0.0
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333


TIME=  60 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3580.6 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        5        2.943       0     0.019
 2        5        2.825       0     0.058
 3        5        2.057       0     0.314
 4       ***       3.000       0     0.0
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333


TIME=  70 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3541.0 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        6        2.943       0     0.019
 2        6        2.825       0     0.058
 3        6        2.057       0     0.314
 4       ***       3.000       0     0.0
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333


TIME=  80 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3501.5 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        7        2.943       0     0.019
 2        7        2.825       0     0.058
 3        7        2.057       0     0.314
 4       ***       3.000       0     0.0
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333
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TIME=  90 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3462.0 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          8         2.349        1      0.217      4
 2          8         2.825        0      0.058
 3          8         2.057        0      0.314
 4        ***         2.757        1      0.081      1
 5        ***         3.000        0      0.0
 6        ***         0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.197
BLUE TOTAL PERCENTAGE OF LOST=0.360


TIME= 100 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3435.6 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          8         1.803        1      0.399      4
 2          9         2.825        0      0.058
 3          9         2.057        0      0.314
 4        ***         2.570        1      0.143      1
 5        ***         3.000        0      0.0
 6        ***         0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.257
BLUE TOTAL PERCENTAGE OF LOST=0.381


TIME= 110 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3409.3 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          8         1.294        1      0.569      4
 2         10         2.825        0      0.058
 3         10         2.057        0      0.314
 4        ***         2.436        1      0.188      1
 5        ***         3.000        0      0.0
 6        ***         0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.314
BLUE TOTAL PERCENTAGE OF LOST=0.396


TIME= 120 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3369.8 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          9         0.810        1      0.730      4
 2         11         2.825        0      0.058
 3         11         2.057        0      0.314
 4        ***         2.352        1      0.216      1
 5        ***         3.000        0      0.0
 6        ***         0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.368
BLUE TOTAL PERCENTAGE OF LOST=0.405
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TIME= 130 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3343.5 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9        0.436       1     0.855     4
 2       12        2.732       1     0.089     4
 3       12        2.057       0     0.314
 4      ***        2.023       1     0.326     1 2
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.419
BLUE TOTAL PERCENTAGE OF LOST=0.442



TIME= 140 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3343.5 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9        0.115       1     0.962     4
 2       12        2.652       1     0.116     4
 3       12        2.057       0     0.314
 4      ***        1.736       1     0.421     1 2
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.464
BLUE TOTAL PERCENTAGE OF LOST=0.474



TIME= 150 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3334.3 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10        0.0         2     1.000     4
 2       12        2.583       1     0.139     4
 3       13        2.057       0     0.314
 4      ***        1.469       1     0.510     1 2
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.484
BLUE TOTAL PERCENTAGE OF LOST=0.503



TIME= 160 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3295.5 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10        0.0         2     1.000
 2       13        2.291       1     0.236     4
 3       14        2.057       0     0.314
 4      ***        1.231       1     0.590     2
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.517
BLUE TOTAL PERCENTAGE OF LOST=0.530
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TIME= 170 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3276.1 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2     1.000
 2       13       2.047        1     0.318     4
 3       15       2.057        0     0.314
 4       ***      1.019        1     0.660     2
 5       ***      3.000        0     0.0
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.544
BLUE TOTAL PERCENTAGE OF LOST=0.553


TIME= 180 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3256.6 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2     1.000
 2       13       1.845        1     0.385     4
 3       16       2.057        0     0.314
 4       ***      0.828        1     0.724     2
 5       ***      3.000        0     0.0
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.566
BLUE TOTAL PERCENTAGE OF LOST=0.575


TIME= 190 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2     1.000
 2       14       1.680        1     0.440     4
 3       17       2.057        0     0.314
 4       ***      0.654        1     0.782     2
 5       ***      3.000        0     0.0
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.585
BLUE TOTAL PERCENTAGE OF LOST=0.594


TIME= 200 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2     1.000
 2       14       1.550        1     0.483     4
 3       17       2.057        0     0.314
 4       ***      0.493        1     0.836     2
 5       ***      3.000        0     0.0
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.599
BLUE TOTAL PERCENTAGE OF LOST=0.612
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TIME= 210 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        14        1.452         1      0.516        4
 3        17        2.057         0      0.314
 4       ***        0.342         1      0.886        2
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.610
BLUE TOTAL PERCENTAGE OF LOST=0.629


TIME= 220 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3179.1 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        15        1.383         1      0.539        4
 3        18        2.057         0      0.314
 4       ***        0.199         1      0.934        2
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.618
BLUE TOTAL PERCENTAGE OF LOST=0.645


TIME= 230 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3179.1 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        15        1.344         1      0.552        4
 3        18        2.057         0      0.314
 4       ***        0.060         1      0.980        2
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.622
BLUE TOTAL PERCENTAGE OF LOST=0.660


TIME= 240 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3583.1 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        10        0.0           2      1.000
 2        15        1.332         1      0.556        4
 3        18        2.057         0      0.314
 4       ***        0.0           2      1.000        2
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667
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TIME= 250 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3543.2 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2      1.000
 2       16       1.332        0      0.556
 3       19       2.057        0      0.314
 4       ***      0.0          2      1.000
 5       ***      3.000        0      0.0
 6       ***      0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667


TIME= 260 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3503.2 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2      1.000
 2       17       1.332        0      0.556
 3       20       2.057        0      0.314
 4       ***      0.0          2      1.000
 5       ***      3.000        0      0.0
 6       ***      0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667


TIME= 270 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3463.3 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2      1.000
 2       18       1.332        0      0.556
 3       21       2.057        0      0.314
 4       ***      0.0          2      1.000
 5       ***      3.000        0      0.0
 6       ***      0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667


TIME= 280 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3423.3 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2      1.000
 2       19       1.332        0      0.556
 3       22       2.057        0      0.314
 4       ***      0.0          2      1.000
 5       ***      3.000        0      0.0
 6       ***      0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667
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TIME= 290 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3383.3 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10        0.0          2       1.000
 2         20        1.332        0       0.556
 3         23        2.057        0       0.314
 4        ***        0.0          2       1.000
 5        ***        3.000        0       0.0
 6        ***        0.0          2       1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667


TIME= 300 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3343.4 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10        0.0          2       1.000
 2         21        1.332        0       0.556
 3         24        2.057        0       0.314
 4        ***        0.0          2       1.000
 5        ***        3.000        0       0.0
 6        ***        0.0          2       1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667


TIME= 310 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3303.4 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10        0.0          2       1.000
 2         22        1.332        0       0.556
 3         25        2.057        0       0.314
 4        ***        0.0          2       1.000
 5        ***        3.000        0       0.0
 6        ***        0.0          2       1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667


TIME= 320 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3263.4 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10        0.0          2       1.000
 2         23        1.332        0       0.556
 3         26        2.057        0       0.314
 4        ***        0.0          2       1.000
 5        ***        3.000        0       0.0
 6        ***        0.0          2       1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667
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TIME= 330 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3223.5 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10        0.0         2      1.000
 2       24        1.332       0      0.556
 3       27        2.057       0      0.314
 4       ***       0.0         2      1.000
 5       ***       3.000       0      0.0
 6       ***       0.0         2      1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667



TIME= 340 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3183.5 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10        0.0         2      1.000
 2       25        1.332       0      0.556
 3       28        2.057       0      0.314
 4       ***       0.0         2      1.000
 5       ***       3.000       0      0.0
 6       ***       0.0         2      1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667



TIME= 350 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3143.6 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10        0.0         2      1.000
 2       26        1.332       0      0.556
 3       29        2.057       0      0.314
 4       ***       0.0         2      1.000
 5       ***       3.000       0      0.0
 6       ***       0.0         2      1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667



TIME= 360 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3103.6 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10        0.0         2      1.000
 2       27        1.332       0      0.556
 3       30        2.057       0      0.314
 4       ***       0.0         2      1.000
 5       ***       3.000       0      0.0
 6       ***       0.0         2      1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 370 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3063.7 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2     1.000
 2       28       1.332        0     0.556
 3       31       2.057        0     0.314
 4       ***      0.0          2     1.000
 5       ***      3.000        0     0.0
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 380 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3023.7 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2     1.000
 2       29       1.332        0     0.556
 3       32       1.462        1     0.513      5
 4       ***      0.0          2     1.000
 5       ***      2.848        1     0.051      3
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.690
BLUE TOTAL PERCENTAGE OF LOST=0.684
```

```
TIME= 390 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3003.7 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2     1.000
 2       30       1.332        0     0.556
 3       32       0.898        1     0.701      5
 4       ***      0.0          2     1.000
 5       ***      2.755        1     0.082      3
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.752
BLUE TOTAL PERCENTAGE OF LOST=0.694
```

```
TIME= 400 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2983.8 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1       10       0.0          2     1.000
 2       31       1.332        0     0.556
 3       32       0.352        1     0.883      5
 4       ***      0.0          2     1.000
 5       ***      2.719        1     0.094      3
 6       ***      0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.813
BLUE TOTAL PERCENTAGE OF LOST=0.698
```

```
TIME= 410 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10       0.0            2     1.000
 2         32       1.224          1     0.592      5
 3         33       0.0            2     1.000      5
 4        ***       0.0            2     1.000
 5        ***       2.592          1     0.136      3 2
 6        ***       0.0            2     1.000
RED TOTAL PERCENTAGE OF LOST=0.864
BLUE TOTAL PERCENTAGE OF LOST=0.712



TIME= 420 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10       0.0            2     1.000
 2         32       0.709          1     0.764      5
 3         33       0.0            2     1.000
 4        ***       0.0            2     1.000
 5        ***       2.519          1     0.160      2
 6        ***       0.0            2     1.000
RED TOTAL PERCENTAGE OF LOST=0.921
BLUE TOTAL PERCENTAGE OF LOST=0.720



TIME= 430 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10       0.0            2     1.000
 2         32       0.209          1     0.930      5
 3         33       0.0            2     1.000
 4        ***       0.0            2     1.000
 5        ***       2.497          1     0.168      2
 6        ***       0.0            2     1.000
RED TOTAL PERCENTAGE OF LOST=0.977
BLUE TOTAL PERCENTAGE OF LOST=0.723



TIME= 440 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         10       0.0            2     1.000
 2         33       0.0            2     1.000      5
 3         33       0.0            2     1.000
 4        ***       0.0            2     1.000
 5        ***       2.497          1     0.168      2
 6        ***       0.0            2     1.000
RED TOTAL PERCENTAGE OF LOST=1.000
BLUE TOTAL PERCENTAGE OF LOST=0.723


*** RED FORCE IS ELIMINATED.  END OF BATTLE.
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FIRE ALLOCATION POLICY 3

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TIME=  10 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3260.1 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        2       3.000        0      0.0
 2        2       3.000        0      0.0
 3        2       3.000        0      0.0
 4       ***      3.000        0      0.0
 5       ***      3.000        0      0.0
 6       ***      3.000        0      0.0
RED TOTAL PERCENTAGE OF LOST=0.0
BLUE TOTAL PERCENTAGE OF LOST=0.0



TIME=  20 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        3       2.800        1      0.067     6
 2        3       2.796        1      0.068     6
 3        3       2.794        1      0.069     6
 4       ***      3.000        0      0.0
 5       ***      3.000        0      0.0
 6       ***      1.879        1      0.374     3 2 1

RED TOTAL PERCENTAGE OF LOST=0.068
BLUE TOTAL PERCENTAGE OF LOST=0.125



TIME=  30 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        3       2.675        1      0.108     6
 2        3       2.669        1      0.110     6
 3        3       2.665        1      0.112     6
 4       ***      3.000        0      0.0
 5       ***      3.000        0      0.0
 6       ***      0.809        1      0.730     3 2 1

RED TOTAL PERCENTAGE OF LOST=0.110
BLUE TOTAL PERCENTAGE OF LOST=0.243



TIME=  40 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3659.7 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        3       2.621        1      0.126     6
 2        3       2.614        1      0.129     6
 3        3       2.610        1      0.130     6
 4       ***      3.000        0      0.0
 5       ***      3.000        0      0.0
 6       ***      0.0          2      1.000     3 2 1

RED TOTAL PERCENTAGE OF LOST=0.128
BLUE TOTAL PERCENTAGE OF LOST=0.333
```

```
TIME=  50 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3620.1 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        4        2.621       0     0.126
 2        4        2.614       0     0.129
 3        4        2.610       0     0.130
 4       ***       3.000       0     0.0
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.128
BLUE TOTAL PERCENTAGE OF LOST=0.333


TIME=  60 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3580.6 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        5        2.621       0     0.126
 2        5        2.614       0     0.129
 3        5        2.610       0     0.130
 4       ***       3.000       0     0.0
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.128
BLUE TOTAL PERCENTAGE OF LOST=0.333


TIME=  70 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3541.0 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        6        2.621       0     0.126
 2        6        2.614       0     0.129
 3        6        2.610       0     0.130
 4       ***       3.000       0     0.0
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.128
BLUE TOTAL PERCENTAGE OF LOST=0.333


TIME=  80 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3501.5 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        7        2.621       0     0.126
 2        7        2.614       0     0.129
 3        7        2.610       0     0.130
 4       ***       3.000       0     0.0
 5       ***       3.000       0     0.0
 6       ***       0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.128
BLUE TOTAL PERCENTAGE OF LOST=0.333
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TIME=  90 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3462.0 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        8        2.026       1     0.325     4
 2        8        2.614       0     0.129
 3        8        2.610       0     0.130
 4      ***        2.790       1     0.070     1
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.194
BLUE TOTAL PERCENTAGE OF LOST=0.357


TIME= 100 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3435.6 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        8        1.474       1     0.509     4
 2        9        2.614       0     0.129
 3        9        2.610       0     0.130
 4      ***        2.637       1     0.121     1
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.256
BLUE TOTAL PERCENTAGE OF LOST=0.374


TIME= 110 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3409.3 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        8        0.952       1     0.683     4
 2       10        2.614       0     0.129
 3       10        2.610       0     0.130
 4      ***        2.539       1     0.154     1
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.314
BLUE TOTAL PERCENTAGE OF LOST=0.385


TIME= 120 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3369.8 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9        0.447       1     0.851     4
 2       11        2.614       0     0.129
 3       11        2.610       0     0.130
 4      ***        2.492       1     0.169     1
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.370
BLUE TOTAL PERCENTAGE OF LOST=0.390
```

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TIME= 130 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3343.5 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        9        0.200         1      0.933      4
 2       12        2.367         1      0.211      4
 3       12        2.610         0      0.130
 4      ***        2.226         1      0.258      1 2
 5      ***        3.000         0      0.0
 6      ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.425
BLUE TOTAL PERCENTAGE OF LOST=0.419
```

```
TIME= 140 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3353.8 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        9        0.0           2      1.000      4
 2       12        2.147         1      0.284      4
 3       12        2.610         0      0.130
 4      ***        2.003         1      0.332      1 2
 5      ***        3.000         0      0.0
 6      ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.472
BLUE TOTAL PERCENTAGE OF LOST=0.444
```

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TIME= 150 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3334.3 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        9        0.0           2      1.000
 2       12        1.750         1      0.417      4
 3       13        2.610         0      0.130
 4      ***        1.822         1      0.393      2
 5      ***        3.000         0      0.0
 6      ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.516
BLUE TOTAL PERCENTAGE OF LOST=0.464
```

```
TIME= 160 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3295.5 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        9        0.0           2      1.000
 2       13        1.388         1      0.537      4
 3       14        2.610         0      0.130
 4      ***        1.678         1      0.441      2
 5      ***        3.000         0      0.0
 6      ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.556
BLUE TOTAL PERCENTAGE OF LOST=0.480
```

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TIME= 170 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3276.1 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        9        0.0            2      1.000
 2       13        1.055          1      0.648       4
 3       15        2.610          0      0.130
 4      ***        1.569          1      0.477       2
 5      ***        3.000          0      0.0
 6      ***        0.0            2      1.000
RED TOTAL PERCENTAGE OF LOST=0.593
BLUE TOTAL PERCENTAGE OF LOST=0.492


TIME= 180 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3256.6 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        9        0.0            2      1.000
 2       13        0.744          1      0.752       4
 3       16        2.610          0      0.130
 4      ***        1.492          1      0.503       2
 5      ***        3.000          0      0.0
 6      ***        0.0            2      1.000
RED TOTAL PERCENTAGE OF LOST=0.627
BLUE TOTAL PERCENTAGE OF LOST=0.501


TIME= 190 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        9        0.0            2      1.000
 2       14        0.447          1      0.851       4
 3       17        2.610          0      0.130
 4      ***        1.445          1      0.518       2
 5      ***        3.000          0      0.0
 6      ***        0.0            2      1.000
RED TOTAL PERCENTAGE OF LOST=0.660
BLUE TOTAL PERCENTAGE OF LOST=0.506


TIME= 200 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

UNIT  LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1        9        0.0            2      1.000
 2       14        0.159          1      0.947       4
 3       17        2.610          0      0.130
 4      ***        1.429          1      0.524       2
 5      ***        3.000          0      0.0
 6      ***        0.0            2      1.000
RED TOTAL PERCENTAGE OF LOST=0.692
BLUE TOTAL PERCENTAGE OF LOST=0.508
```

```
TIME= 210 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3231.1 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         9         0.0          2      1.000
 2        14         0.0          2      1.000        4
 3        17         2.610        0      0.130
 4       ***         1.429        1      0.524        2
 5       ***         3.000        0      0.0
 6       ***         0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.710
BLUE TOTAL PERCENTAGE OF LOST=0.508
```

```
TIME= 220 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3193.2 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         9         0.0          2      1.000
 2        14         0.0          2      1.000
 3        18         2.610        0      0.130
 4       ***         1.429        0      0.524
 5       ***         3.000        0      0.0
 6       ***         0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.710
BLUE TOTAL PERCENTAGE OF LOST=0.508
```

```
TIME= 230 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3155.4 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         9         0.0          2      1.000
 2        14         0.0          2      1.000
 3        19         2.327        1      0.224        4
 4       ***         1.188        1      0.604        3
 5       ***         3.000        0      0.0
 6       ***         0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.741
BLUE TOTAL PERCENTAGE OF LOST=0.535
```

```
TIME= 240 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3155.4 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         9         0.0          2      1.000
 2        14         0.0          2      1.000
 3        19         2.091        1      0.303        4
 4       ***         0.971        1      0.676        3
 5       ***         3.000        0      0.0
 6       ***         0.0          2      1.000
RED TOTAL PERCENTAGE OF LOST=0.768
BLUE TOTAL PERCENTAGE OF LOST=0.559
```

```
TIME= 250 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3155.4 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          9        0.0           2       1.000
 2         14        0.0           2       1.000
 3         19        1.899         1       0.367       4
 4        ***        0.774         1       0.742       3
 5        ***        3.000         0       0.0
 6        ***        0.0           2       1.000
RED TOTAL PERCENTAGE OF LOST=0.789
BLUE TOTAL PERCENTAGE OF LOST=0.581
```

```
TIME= 260 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3117.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          9        0.0           2       1.000
 2         14        0.0           2       1.000
 3         20        1.745         1       0.418       4
 4        ***        0.593         1       0.802       3
 5        ***        3.000         0       0.0
 6        ***        0.0           2       1.000
RED TOTAL PERCENTAGE OF LOST=0.806
BLUE TOTAL PERCENTAGE OF LOST=0.601
```

```
TIME= 270 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3117.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          9        0.0           2       1.000
 2         14        0.0           2       1.000
 3         20        1.627         1       0.458       4
 4        ***        0.425         1       0.858       3
 5        ***        3.000         0       0.0
 6        ***        0.0           2       1.000
RED TOTAL PERCENTAGE OF LOST=0.819
BLUE TOTAL PERCENTAGE OF LOST=0.619
```

```
TIME= 280 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3117.7 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1          9        0.0           2       1.000
 2         14        0.0           2       1.000
 3         20        1.543         1       0.486       4
 4        ***        0.265         1       0.912       3
 5        ***        3.000         0       0.0
 6        ***        0.0           2       1.000
RED TOTAL PERCENTAGE OF LOST=0.829
BLUE TOTAL PERCENTAGE OF LOST=0.637
```

```
TIME= 290 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3080.0 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9        0.0         2     1.000
 2       14        0.0         2     1.000
 3       21        1.490       1     0.503      4
 4      ***        0.110       1     0.963      3
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.834
BLUE TOTAL PERCENTAGE OF LOST=0.654
```

```
TIME= 300 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3423.4 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9        0.0         2     1.000
 2       14        0.0         2     1.000
 3       21        1.468       1     0.511      4
 4      ***        0.0         2     1.000      3
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 310 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3423.4 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9        0.0         2     1.000
 2       14        0.0         2     1.000
 3       21        1.468       0     0.511
 4      ***        0.0         2     1.000
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

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TIME= 320 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3383.7 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9        0.0         2     1.000
 2       14        0.0         2     1.000
 3       22        1.468       0     0.511
 4      ***        0.0         2     1.000
 5      ***        3.000       0     0.0
 6      ***        0.0         2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
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```
TIME= 330 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3344.0 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9       0.0          2     1.000
 2       14       0.0          2     1.000
 3       23       1.468        0     0.511
 4      ***       0.0          2     1.000
 5      ***       3.000        0     0.0
 6      ***       0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

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TIME= 340 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3304.3 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9       0.0          2     1.000
 2       14       0.0          2     1.000
 3       24       1.468        0     0.511
 4      ***       0.0          2     1.000
 5      ***       3.000        0     0.0
 6      ***       0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 350 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3264.6 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9       0.0          2     1.000
 2       14       0.0          2     1.000
 3       25       1.468        0     0.511
 4      ***       0.0          2     1.000
 5      ***       3.000        0     0.0
 6      ***       0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 360 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3224.9 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9       0.0          2     1.000
 2       14       0.0          2     1.000
 3       26       1.468        0     0.511
 4      ***       0.0          2     1.000
 5      ***       3.000        0     0.0
 6      ***       0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 370 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3185.2 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9       0.0          2     1.000
 2       14       0.0          2     1.000
 3       27       1.468        0     0.511
 4      ***       0.0          2     1.000
 5      ***       3.000        0     0.0
 6      ***       0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 380 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3145.5 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9       0.0          2     1.000
 2       14       0.0          2     1.000
 3       28       1.468        0     0.511
 4      ***       0.0          2     1.000
 5      ***       3.000        0     0.0
 6      ***       0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 390 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3105.9 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9       0.0          2     1.000
 2       14       0.0          2     1.000
 3       29       1.468        0     0.511
 4      ***       0.0          2     1.000
 5      ***       3.000        0     0.0
 6      ***       0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 400 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3066.2 M

UNIT  LOCATION  FORCE LEVEL  STATUS  LOST-PCT  TARGETS
 1        9       0.0          2     1.000
 2       14       0.0          2     1.000
 3       30       1.468        0     0.511
 4      ***       0.0          2     1.000
 5      ***       3.000        0     0.0
 6      ***       0.0          2     1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 410 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3026.5 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         9        0.0           2      1.000
 2        14        0.0           2      1.000
 3        31        1.468         0      0.511
 4       ***        0.0           2      1.000
 5       ***        3.000         0      0.0
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667
```

```
TIME= 420 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2986.9 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         9        0.0           2      1.000
 2        14        0.0           2      1.000
 3        32        0.874         1      0.709        5
 4       ***        0.0           2      1.000
 5       ***        2.909         1      0.030        3
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.903
BLUE TOTAL PERCENTAGE OF LOST=0.677
```

```
TIME= 430 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2986.9 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         9        0.0           2      1.000
 2        14        0.0           2      1.000
 3        32        0.297         1      0.901        5
 4       ***        0.0           2      1.000
 5       ***        2.879         1      0.040        3
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=0.967
BLUE TOTAL PERCENTAGE OF LOST=0.680
```

```
TIME= 440 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2986.9 M

UNIT   LOCATION   FORCE LEVEL   STATUS   LOST-PCT   TARGETS
 1         9        0.0           2      1.000
 2        14        0.0           2      1.000
 3        32        0.0           2      1.000        5
 4       ***        0.0           2      1.000
 5       ***        2.879         1      0.040        3
 6       ***        0.0           2      1.000
RED TOTAL PERCENTAGE OF LOST=1.000
BLUE TOTAL PERCENTAGE OF LOST=0.680


*** RED FORCE IS ELIMINATED.  END OF BATTLE.
```

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